# IOWA STATE COLLEGE

# OURNAL OF SCIENCE

### A Quarterly of Research

## CONTENTS

# ABSTRACTS OF DOCTORAL DISSERTATIONS

Accepted July 1, 1952 - June 30, 1953

These abstracts are arranged in alphabetical order by names of the authors. The ·st page of each abstract carries also the serial number of the dissertation, the date acceptance of the thesis by the Graduate College, the name of the chairman of the udent's committee, the degrees held by the author, and the candidate's academic posi- on (if any) in the several research institutes of Iowa State College.

The following summaries and indices may prove helpful to those interested in tabu- tions and to those who wish to examine groups of abstracts of theses in the same or lated fields.

. DOCTORAL DISSERTATIONS ACCEPTED JULY 1, 1952 - June 30, 1953. 121.
Number of Doctor of Philosophy degrees conferred on candidates on whom first de- grees were conferred by:
a. Institutions other than Iowa State College - 100
b. Iowa State College - 21

. INDEX TO THESES BY DEPARTMENTS. Double indexing is used in those cases in rhich two departments are jointly responsible. The departments are arranged alpha- betically. Under each department are listed alphabetically the names of the authors.

3. INDEX TO THESES BY RESEARCH INSTITUTES THAT PROVIDED RESEARCH FA-
CILITIES. A graduate school can function only where there are adequate opportunities
for research. The existence on the campus of Iowa State College of six research insti-
tutes well integrated into the college programs is in large measure responsible for the
growth of the graduate work. These institutes have frequently assumed the responsi-
bility of providing research facilities necessary for the doctoral candidates in their re-
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their researches by use of workers who are in a sense apprentices of research. Under
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Mickey.

4. Alphabetical Index to Authors of Abstracts of Doctoral Theses.

## SEPARATION OF NUCLEIC ACID COMPONENTS FROM SOIL AND IDENTIFICATION BY CHROMATOGRAPHIC TECHNIQUES[1]

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Organic phosphorus in the soil constitutes a major portion of the total soil phosphorus. This organic phosphorus undoubtedly plays an important role in the nutrition of the plants. In order to better understand the factors affecting the availability of organic phosphorus to plants it is necessary to understand its composition. Previous workers have proposed that the organic phosphorus was composed of four different groups of compounds; namely, inositol phosphorus, nucleic acid, lipid phosphorus, and phosphorylated metabolic intermediates. The latter two have been shown to be present in very small quantities. It was believed, therefore, that the soil organic phosphorus was largely composed of inositol phosphate and nucleic acid. Good quantitative estimates have been made of the amount of inositol phosphorus occurring in soils, but the information on the occurence of nucleic acid has been mainly of an indirect nature.

This study was instigated for the purpose of determining the quantity of nucleic acid in soil. A combination of chromatographic and spectrophotometric techniques was employed.

Several methods of soil extraction were tested and a method was developed, using 1N NaOH for 19 hours at 30° C. The alkaline extract thus obtained was acidified and the humic material precipitated. The nucleotides contained in the acidified filtrate were adsorbed onto activated alumina to separate them from excess salt. Removal of the nucleotides from alumina was accomplished with dilute $NH_4OH$. Concentration of the organic phosphorus solution and removal of the ammonia were effected by vacuum distillation.

The concentrated phosphorus solution was adjusted to a pH of 8 and adsorbed

onto a column of Dowex A-1, a strong base anion exchanger. Elution of the adsorbed compound was effected by leaching the column with dilute solutions of HCl. The eluant was collected in several fractions by the use of an automatic fraction collector. Organic phosphorus determinations were made on the eluant fractions and the data obtained were plotted to give an ion-exchange graph.

Several columns containing soil extracts, combinations of soil extracts, and nucleic acid were prepared and eluted simultaneously so that their elution patterns could be better compared.

Spectrophotometric studies were made on the fractions of the eluted material which appeared to be similar to nucleic acid products. The ultraviolet absorption curves obtained from the soil extract eluants were then compared with those of nucleic acid components treated in the same way. Quantitative estimates were made of the amounts of nucleic acid in the soils studied. The data indicated that the Carrington soil did not contain more than 1 and the Webster not more than 6 ppm. of ribonucleic acid phosphorus. The above method is a specific test for nucleic acid components and offers a sound basis for estimating the maximum amounts in the soil.

Incubation studies were made to compare the dephosphorylation rates of desoxyribonucleic and ribonucleic acid in sand and soil cultures. The results indicated that both of these substances undergo rapid dephosphorylation in the soil.

Acid hydrolysates of soil organic matter were tested for the presence of purine bases. Soil extracts were compared on paper chromatograms with known materials. The developed chromatograms were scanned with ultraviolet light and no migration of purines from the soil could be detected.

All of the evidence obtained in this study indicates that only very small quantities of nucleic acid are present in soil. The large fraction of soil organic phosphorus has yet to be identified chemically.

1 a. Chairman of Committee, W. V. Bartholomew, Dept. of Agronomy.
   b. Doctoral Thesis No. 1366. Submitted
     March 10, 1953.
2 a. B.S. Brigham Young University,
     Provo, Utah, 1948.
   b. Graduate Assistant, Agricultural
     Experiment Station.

## A MODEL FOR THE STUDY OF QUANTITATIVE INHERITANCE[1]

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Department of Statistics

The actions of genes controlling quantitative characters may be described by gene models. Complicated models may be devised which will describe the gene actions completely, but these models would undoubtedly be of no practical utility. Geneticists have devised simple models to describe the simple additive gene actions but have not been successful in devising a simple model which will describe interactions of genes as well as the additive action. The present work was undertaken to investigate possibilities of obtaining a model of the latter type. The result of the investigation was the adaptation and utilization of the factorial model for quantitative inheritance problems.

The factorial gene model, based on the factorial model used in the design of experiments, was developed. The comparisons in the population of all possible genotypes using this model allow that the heterozygotes have twice the weight of the homozygotes. As a result, the model for the genotypic value of an individual represented by $a_i b_j c_k \ldots$, that is, an individual in which the a locus is in the $i^{th}$ phase, the b locus is in the $j^{th}$ phase and so on (i, j, $\ldots$ = 0, 1 or 2 dominant alleles present at that locus), is

$$\mu + A_i + B_j + A_i B_j + C_k + A_i C_k + B_j C_k + A_i B_j C_k + \ldots$$

where:

(a) $a_i b_j c_k \ldots$ = genotypic value for a character with any number of loci, e.g., $a_1 = Aa$, $a_2 = AA$ and $a_0 b_1 = aaBb$,

(b) $\mu$ = overall mean,

(c) $A_0 = 1/4 (3a_0 - 2a_1 - a_2)$ evaluated over all the possible combinations for all other loci,

(d) $A_1 = 1/4 (-a_0 + 2a_1 - a_2)$ evaluated over all the possible combinations for all other loci,

(e) $A_2 = 1/4 (-a_0 - 2a_1 + 3a_2)$ evaluated over all the possible combinations for all other loci,

1 a. Chairman of Committee, Oscar Kempthorne, Dept. of Statistics.
   b. Doctoral Thesis No. 1382. Submitted April 21, 1953.
2 a. B.S. Iowa State College, Ames, Iowa, 1947.
   b. Graduate Assistant, Agricultural Experiment Station.

(f) Similarly for $B_j$ (j = 0, 1 or 2), $C_k$(k = 0, 1 or 2) and so on,

(g) $A_i B_j$ = product of $A_i$ and $B_j$ (for all i and j) evaluated over all other loci,

(h) Similarly for $A_i C_k$, $B_j C_k$ (for all i, j and k) and so on evaluated over all other loci,

(i) $A_i B_j C_k$ = produce of $A_i$, $B_j$ and $C_k$ (for all i, j and k), evaluated over all other loci, and

(j) Similarly all other combinations are found by products.

This model contains the following desirable features of a gene model:
(a) Additivity of the parameters,
(b) Parameters which have genetical interpretation,
(c) Applicability to a genotypic value for any number of loci,
(d) Symmetry with respect to the expressions for the homozygous loci and
(e) Flexibility of the model with respect to increasing assumptions.

The factorial gene model was applied to populations obtained by successively selfing for m generations populations originating from one heterozygous individual. The total genotypic array in the m generation is

$$\left[1/2(1-q)aa + qAa + 1/2(1-q)AA\right]$$
$$\left[1/2(1-q)bb + qBb + 1/2(1-q)BB\right] \ldots$$
$$\ldots \left[1/2(1-q)pp + qPp + 1/2(1-q)PP\right]$$

and so on, where q is equal to $1/2^m$. To obtain the mean genotypic value, we may substitute the genotypic value from the model for each genotype, use the restrictions of the form $A_0 + 2A_1 + A_2 = 0$ and find the p-factor interaction for the variable loci. Then, defining
$K_1$ = overall average effect plus the effects and interactions of fixed loci,
$\beta_1$ = loci effect of the variable loci plus the interaction of these effects with the fixed loci.
$\beta_2$ = the interaction of all possible pairs of variable loci plus the interaction of these interactions with the fixed loci, and so on,
we obtain the general formula for the mean genotypic value of the population produced by m generations of selfing as

$$F_m = K_1 + \sum_{p=1}^{n} \left(\frac{1}{2^{m-1}} - 1\right)^p \beta_p$$

where $\beta_p$ is the contribution of the p-factor interaction.

The model was used on data given by Khambanonda (1). It was shown that epistasis may contribute considerably to inbreeding depression. Loci effects and epistatic parameters along with their standard errors were estimated from these data, and it was found in almost all cases that the epistatic contribution differed significantly, at the 5 per cent level, from zero.

The model was applied to populations which arise by crossing two inbred lines and subsequent crossing and selfing. For the two parent case a method of expressing the loci in groups were evolved. The loci fall into groups within which the loci have identical phase relationships to the parents. We may describe the parents as

| Parent | Loci group | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| $P_1$ | R | D | R | D |
| $P_2$ | R | R | D | D |

where R and D are equivalent to phases 0 and 2, respectively, given earlier. For any cross arising from these two parents, loci group two specifies the genotype completely.

The genotypic array for the variable loci is

$\pi$    $(pR+qH+rD)$   $\pi$   $(rR+qH+pD)$.
loci of               loci of
group two            group three

Inserting the factorial model and expanding, we obtain the total effect contribution as

$\Sigma$   (effects) + $\Sigma$   $(pA_0+qA_1+rA_2)$
loci groups        loci of
one and four       group two

+ $\Sigma$   $(rB_0 + qB_1 + pB_2)$.
   loci of
   group three

Using the restrictions of the form $A_0 + 2A_1 + A_2 = 0$, we may acquire expressions for any genotypic value arising from the specified two parents in terms of $K_2$, the overall average effect plus the loci effects and interactions of fixed loci; E and F, the loci effects of the variable loci plus the interaction of these effects with the fixed loci; and G, L and M, the interactions of all possible pairs of variable loci plus the interaction of these interactions with the fixed loci.

The model was employed on data given

by Stringfield (3). The results showed that epistatic contributions were an important part of the observed mean genotypic values. The flexibility of the model was shown by assuming no epistasis was present, dropping the interaction parameters and obtaining the usual estimates,

$$\hat{F_2} = 1/4(P_1 + P_2 + 2F_1)$$
$$\hat{P_1F_1} = 1/2(P_1 + F_1)$$
$$\hat{P_2F_1} = 1/2(P_2 + F_1).$$

It was shown that scaling tests described by Mather (2) were not necessarily tests of absence of epistasis. In fact, only if the interactions of three and more loci are zero are the scaling tests even tests of the absence of the interaction of all possible pairs of loci.

The model was applied to the case in which three inbred parents are crossed and the usual subsequent crosses are obtained. In this case there were eight loci groups, but only three of them were necessary to specify any of the genotypic values completely.

The same general procedure for obtaining the expression of the genotypic value for any genotype in the two parent case was used for the three parent case. From the same set of data used in the two parent case, estimates of the genetic parameters were obtained and it was shown again that epistasis was not negligible for the characters investigated in these data. Flexibility of the factorial model was demonstrated by assuming there was no epistasis for both the three and four parent cases and obtaining the usual estimates for the three way crosses and double crosses, respectively.

## REFERENCES

1. Khambanonda, I. Polygenic inheritance of fruit size in red pepper. Unpublished Ph.D. Thesis. Ames, Iowa, Iowa State College Library. 1948.

2. Mather, K. Biometrical Genetics. Dover Publishings, Inc. 1949.

3. Stringfield, G.H. Senior Agronomist, Agricultural Experiment Station, Wooster, Ohio. (Data obtained by personal communication).

## LABORATORY ESTIMATION OF THE BIOLOGICAL VALUE OF
## SOYBEAN OIL MEAL AS RELATED TO METHOD OF PREPARATION

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The correlation of several laboratory tests with the nutritive value of soybean oil meal for chicks has been studied. As a necessary part of this evaluation, data were obtained on growth, feed consumption, feed efficiency and blood-clotting time of chicks fed diets containing different soybean oil meals.

The growth-inhibitor of raw soybean oil meal was progressively inactivated by autoclaving, with substantially complete inactivation when the meal had been autoclaved 20 minutes at 15 pounds steam pressure. This was indicated by maximum growth and optimum feed efficiency when chicks were fed diets containing soybean oil meal autoclaved 20 minutes. Either more or less heat produced a meal of sub-optimum nutritive value. The growth stimulation was not entirely due to a greater availability of the autoclaved soybean protein since chick growth was retarded when 10 or 15 per cent of underheated soybean oil meal was added to a diet containing adequate amounts of high-quality soybean oil meal. Heating soybean oil meals for periods longer than 20 minutes reduced tne lysine content and the nutritive value of the meals.

Urease activity was a satisfactory measure of heating soybean oil meals up to the point of optimum heating, but was of no value in determining overheating. The titration of the ammonia released from added urea by the urease enzyme was a more precise measure of adequacy of heat treatment than was the measurement of pH change by the technique of Caskey and Knapp (1944).

Fluorescence, as measured by the method of McGinnis (1949), increased markedly when solvent-extracted soybean oil meal was autoclaved beyond the point of maximum nutritive value. There was no significant increase in fluorescence of unheated meals when they were autoclaved just sufficiently for production of maximum meal quality. Expeller meals were high in fluorescing properties when optimally heated or even when underheated.

A determination of water-soluble protein revealed a sharp decrease in this fraction when solvent-extracted soybean oil meals were autoclaved at 15 pounds steam pressure for periods up to 20 minutes. Beyond this time, further autoclaving produced only minor reductions in the water-soluble fraction of the protein.

Blood-clotting time of chicks was demonstrated to be greatly increased by the feeding of diets containing underheated, solvent-extracted soybean oil meal. This was not reduced by the addition of vitamin K, but autoclaving the soybean oil meal abolished the anti-blood-clotting properties completely.

Trichloroethylene-extracted soybean oil meal, previously shown to have toxic properties for dairy calves, proved to be non-toxic to chicks and of as high nutritive value for growth and reproduction as a commercially processed hexane-extracted soybean oil meal.

### REFERENCES

Caskey, C. S. and F. Knapp, Method for determining inadequately heated soybean meal. Ind. Eng. Chem. (Anal. Ed.) 16:640-641. 1944.

McGinnis, J., Pullman, Wash. Method for determining fluorescence of soybean meal. (Private communication). 1949.

## STRUCTURE OF THE RARE EARTH METALS AT LOW TEMPERATURES[1]

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Department of Physics

Three members of the rare earth metal series are known to be ferromagnetic at low temperatures. These are gadolinium, dysprosium, and erbium. The Curie point of gadolinium is 289 degrees Kelvin while that of erbium is $56 \pm 2$ degrees Kelvin. Dysprosium shows a magnetic anomaly at about 180 degrees Kelvin and a ferromagnetic Curie point at 105 degrees Kelvin. This study was undertaken because the onset of the ferromagnetic condition is often accompanied by anomalous behavior of the coefficient of thermal expansion.

The nature of the problem required a low temperature X - ray camera which could be used over a wide temperature range. Such a camera of the Debye-Scherrer type was designed and constructed. The X-ray sample was held at the desired exposure temperature by a gas stream which flowed by it. To reduce the heat leak, the camera interior was insulated except for a small free volume through which X-rays passed.

Several methods were employed to obtain the gas stream used for temperature control. Exposures above room temperature were obtained using a stream of helium which was electrically heated. For a few of the low temperature exposures, the X-ray sample was cooled with a stream of gas evaporated from a bath. Most of the low temperature exposures were ob-

tained by another method in which the sample was cooled with a circulating stream of working gas. The working gas was cooled by use of a gas heat exchanger system as well as a coil submerged in the bath. The working gas returning from the camera and the gas evaporated from the bath were used to cool the working gas entering the cycle. Temperature control was obtained by mixing working gas at various temperatures and varying flow rates.

The X-ray samples were prepared by first annealing filings in a vacuum and then mixing sodium chloride with the filings before placing them in an X-ray capillary. The sodium chloride was used as an internal standard.

Exposures were obtained of gadolinium in a temperature range from 106 degrees Kelvin to 349 degrees Kelvin. For dysprosium the temperature range in which exposures were obtained was from 49 degrees Kelvin to 300 degrees Kelvin. The exposure temperature range of erbium was from 43 degrees Kelvin to 301 degrees Kelvin.

The structure of all three metals was found to be hexagonal close-packed for all exposures. The average values for the lattice constants at room temperature are summarized in the following table.

Table 1

Room Temperature Lattice Parameters of
Gadolinium, Dysprosium, and Erbium

|  | $a_0$ | $c_0$ |
|---|---|---|
| Gadolinium | $3.635 \pm .002 \text{Å}$ | $5.775 \pm .005 \text{Å}$ |
| Dysprosium | $3.596 \pm .002 \text{Å}$ | $5.653 \pm .004 \text{Å}$ |
| Erbium | $3.562 \pm .002 \text{Å}$ | $5.602 \pm .003 \text{Å}$ |

Anomalous behavior of the same type was noted for all three metals. Below the Curie point the $c_0$ parameter increased with decreasing temperature. In the cases of dysprosium and erbium the rates of decrease of the $a_0$ parameter with temperature were somewhat larger below the Curie point.

The unusual behavior was considered to be due to the increase of the magnetization in the domains with decreasing temperature below the Curie point. Furthermore the data were thought to suggest a close correlation between the directions of magnetization in the domain and the crystal directions. A qualitative discussion was included of the possible theoretical basis of the effect. It was assumed that the direction of easy magnetization in the domain was identical with the direction of the $c_0$ axis of the crystal. The observed result could then be regarded as magneto striction due to the field within the domains.

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## THE PREPARATION OF THE SUPEROXIDES OF THE ALKALINE EARTH METALS[1]

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Department of Chemistry

This investigation was undertaken to determine if the alkaline earth metals formed a superoxide by the action of hydrogen peroxide on different alkaline earth metal salts, and to study the effect of the concentration of the hydrogen peroxide on the superoxide content of the products.

All references in the literature regarding the action of hydrogen peroxide on alkaline earth metal salts reported the formation of various hydrates of the alkaline earth metal peroxides. Most of these preparations were described as varying in color from white to light yellow. A few investigators postulated the existance of a small amount of a higher oxide in these preparations on the basis of the oxygen evolved upon decomposition.

The first part of the experimental work resolved itself into an investigation of the action of various concentrations of hydrogen peroxide on barium salts. The resultant products were analyzed and treated in various ways in an attempt to determine which method of treatment resulted in a high total oxygen content.

A method of preparing very pure barium peroxide octahydrate was established. When a saturated barium hydroxide solution, protected from carbonate formation, was allowed to pass directly into a 0.3% solution of hydrogen peroxide at 0° C., pure white crystals of barium peroxide octahydrate were formed. This compound, when heated in a 100°-110° C.

oven for a period of twenty-four hours or when placed in a desiccator over anhydrous $P_2O_5$ for a period of several days, resulted in a pure form of the metal peroxide.

It was established that all concentrations of hydrogen peroxide, of 3%,or higher, gave a product which was buff to light yellow in color when a saturated solution of barium hydroxide was allowed to pass into a chilled solution of the hydrogen peroxide. These preparations showed a high total oxygen content.

The second part of the experimental work, which constituted the major part of the investigation, was concerned with the treatment of salts of the three alkaline earth metals with various concentrations of hydrogen peroxide. These preparations were analyzed for per cent metal oxide, per cent total oxygen, and per cent superoxide oxygen.

An apparatus, modified from that described by Seyb and Kleinberg (J. Am. Chem. Soc., 73 : 2308. 1915), was constructed. The method of determination of superoxide oxygen, in mixtures of superoxide and peroxide, described by these authors was followed. The basis of this determination depended upon the treatment of such mixtures with a glacial acetic acid-diethyl phthalate solution at 0° C. With this reagent only two-thirds of the total available oxygen from the superoxide was liberated, and none of the peroxide oxygen was decomposed. The total available oxygen of the mixture was determined by decomposition of the sample with a hydrochloric acid solution containing a high concentration of ferric chloride.

A comparison of the gasometric and titrimetric method of analysis for total oxygen content was made on an analyzed sample of potassium superoxide. This was done when it was seen that the determination of total oxygen content of some

barium peroxide preparations by the gaso-metric method always gave a larger value than when this determination was carried out by the titration of the acidified sample with standard permanganate solution. It was shown that only one-third of the total oxygen from superoxides was detected by the titrimetric method.

The analysis of a sample of barium per-oxide, which had remained over $P_2O_5$ in an evacuated desiccator for nearly a year, was shown to contain a small percentage of barium superoxide. Several series of experiments were then carried out to de-termine the effect of the concentration of hydrogen peroxide on the superoxide oxy-gen content of the products formed when various alkaline earth metal salts were treated with hydrogen peroxide. Concen-trations of hydrogen peroxide used ranged from 0.3% to 90%.

A saturated solution of each of the alka-line earth metal hydroxides was added to the hydrogen peroxide at 0° C. A portion of each of these preparations was analyzed immediately, while another portion was analyzed after ninety hours over $P_2O_5$. All of these preparations gave a relative-ly low superoxide content in the product. After ninety hours over $P_2O_5$, the pro-ducts analyzed slightly higher in super-oxide content.

The dry peroxide and the peroxide octa-hydrate of each of the alkaline earth met-als were treated with various concentra-tions of hydrogen peroxide at room tem-perature for approximately one day fol-lowed by analysis of the product. It was found that treatment of the peroxide octa-hydrate with the same concentration of hydrogen peroxide, in almost all cases, gave a product containing a higher super-oxide content than similar treatment of the anhydrous peroxide.

The treatment of strontium and barium compounds with the same concentration of hydrogen peroxide invariably gave a pro-duct with a considerably higher superox-ide content than the treatment of the cor-responding calcium compound.

Approximately thirteen per cent of the product by weight was the highest concen-tration of metal superoxide obtained in any of the preparations made. This was the approximate metal superoxide content of the preparation obtained by the action of 30% $H_2O_2$ on barium peroxide octahy-drate, 50% $H_2O_2$ on the corresponding strontium compound, and 90% $H_2O_2$ on calcium peroxide octahydrate.

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## FACTORS RELATED TO PARTICIPATION IN FARMER COOPERATIVES[1]

GEORGE M. BEAL[2]
Department of Economics and Sociology

The American culture is noted for its many forms of formal voluntary associa-tions. Sociologists have been actively en-gaged in studying this rather unique form of human togetherness in a framework that has been termed social participation research. The focus of this study is on participation in a single sub type of for-mal voluntary association, the farmer co-operative.

Most past research in farmer coopera-tives has dealt with the two major areas of farmer opinions and attitudes toward cooperatives and of farmer knowledge of facts about cooperatives. Little detailed research has been done on what appeared

to the author to be two important areas of cooperative research: (1) farmer partici-pation in cooperative activity, and (2) farmer understanding of basic cooperative theory and principles.

The major purpose of this dissertation was to determine whether selected factors were related to different degrees of par-ticipation of people in farmer cooperatives. In addition, two minor objectives were: (1) to determine if generalizations from past general participation research would apply to a specific formal voluntary asso-ciation, farmer cooperatives, and (2) to suggest and test hypotheses that might be useful for future research in the field of social participation.

In consultation with the Iowa State Col-lege Statistical Laboratory a sample of 22 Iowa communities was chosen and a total of 268 cooperative member and 278 non-member schedules were taken from farm-ers living in these communities in 1948.

A review of past research in social par-

1 a. Chairman of Committee, Ray E. Wakeley, Dept. of Economics and Sociology.
   b. Doctoral Thesis No. 1419. Submitted June 8, 1953.
2 a. B.S. Iowa State College, Ames, Iowa, 1943.
   M.S. Ibid., 1947.
   b. Assistant, Agricultural Experiment Station.

ticipation did not reveal an acceptable device for the measurement of participation in farmer cooperatives. The unique nature of farmer cooperatives as economic associations was studied and eight major elements of cooperative participation were determined as follows: (1) use of plant or patronage, (2) decision making regarding the plant and its operations, (3) accepting financial responsibility, (4) sharing fixed and variable costs of operating the plant, (5) accepting responsibilities for risks and uncertainties, (6) sharing economic benefits from the plant, (7) participation to get facts and understanding, and (8) organizational maintenance duties. Using these elements as the framework a cooperative participation score composed of 12 items was constructed by the author and a panel of three judges.

An important part of past social participation research has been the comparison of those people who belong to some type of formal association with those who do not belong. Members and nonmembers of farmer cooperatives were first compared to determine if there were any significant differences between these two categories. Propositions were suggested that members and nonmembers would differ significantly when compared on the basis of the following factors: age, educational level, stage of family cycle, nationality background, number of years farmed, size of farm in acres, general social participation, participation in informal cooperative ventures, and socio-economic status. With the exception of the factor, educational level, the findings from the present study supported the propositions involving the above factors--members and nonmembers differed significantly when compared on the basis of these factors.

Propositions were suggested that members and nonmembers would not differ significantly when compared on the basis of the following factors: family composition, length of residence in the community, tenure status, and type of farming. With the exception of the factor, type of farming, the findings from the present study supported the propositions involving the factors listed directly above.

Propositions were suggested that cooperative participation scores of members would differ significantly when compared on the basis of the following factors: general social participation, membership in other farm organizations, socio-economic status, member understanding of basic cooperative principles, member definition of the cooperative as an agent or just another place to do business, member feel-

ing of responsibility, member opinion regarding 100 per cent participation, member feeling of say or no say in running the cooperative, member "we feeling" or identity with the cooperative, number of neighbors who belong to the cooperative, receiving or not receiving current information about the cooperative, more information desired about local cooperative, more information desired about cooperatives in general, knowledge of facts about the local cooperative, knowledge of the existence of wholesale or "regional" cooperatives, greatest benefit from cooperatives, criticisms or no criticisms of cooperatives, specific cooperative named most important by member, community in which member resided, and size of community. In all cases the present findings supported the propositions that participation scores of members would differ significantly when compared on the basis of these factors.

Propositions were suggested that participation scores of members would differ significantly when compared on the basis of the following factors: educational level, participation in informal cooperative ventures, reasons for joining the cooperative, urgency of need at the time the member joined, stated responsibilities to cooperative, justification for not always patronizing the local cooperative, source of current information about cooperatives, type of criticisms named by members, type of cooperative, size of cooperative, and number of educational programs. However, the present findings did not support any of the suggested propositions involving the above factors.

Propositions were suggested that participation scores would not differ significantly when compared on the basis of the following factors: age, stage of family cycle, tenure status, number of years farmed, size of farm in acres, source of first information about cooperatives, number of cooperatives to which member belonged, number of years the member had belonged to the cooperative, type of educational program, and separate educational fund in cooperative. In all cases the propositions involving the factors listed above were supported by the findings of the present study.

A minor objective of this dissertation was to determine the degree to which research finding's from other studies agreed with findings from the present study. Past research findings were cited in relation to 40 of the 58 hypotheses tested. In 11 of the 40 cases past research findings were not in agreement. The findings from the present study agreed with past research

ndings in 17 of the 29 cases where there
as agreement among the past findings.
the present findings did not agree with
ast findings in ten cases and in two cases
ast research findings were not accepted
or farmer cooperatives for logical rea-
rons.

The findings from the present study have
demonstrated that the framework of parti-
cipation can be productive in cooperative
research. As additional research is plan-
ned the following points should be consid-
ered: (1) the inter-disciplinary approach
to the problem, (2) the improvement of

the measurement of cooperative partici-
pation, (3) the improvement of the meas-
urement of understanding of basic theory
of cooperatives, (4) the incorporation of
the concept of optimum rational partici-
pation in cooperatives into the research
plan, (5) the choice of the population to
be studied that will allow for (a) compari-
sons of cooperatives and communities and
(b) the study of cooperative structure and
process in individual cooperatives and
their relation to participation, and (6) the
further quantification of data to aid in sta-
tistical treatment.

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## A ROUND-OFF THEORY FOR SCALAR PRODUCTS[1]

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Since the introduction of high speed cal-
culating machines, the time and effort re-
quired to solve a linear system have be-
come relatively small. However, other
problems arise. For instance, for large
systems where the number of operations
required is no longer relatively small, a
new need is felt for a round-off theory.
This paper, starting with the basic sym-
bols, definitions and inequalities of a
theory developed by J. von Neumann and
H. H. Goldstine (1), extends their theory
and applies it to a method of inverting ma-
trices which uses powers, and to a com-
parison of the exact solutions and pseudo-
solutions of a linear equation, where the
latter are solutions which pseudo-check
as explained below. In addition, maximum
permissible absolute values of the coeffi-
cients of a matrix are determined, using
strict and probabilistic considerations, in
order that relevant higher powers of the
matrix be digital.

The Bingham Method is selected to de-
termine the inverse of a matrix. This
method requires that the first n-1 powers
and the diagonal elements of the $n^{th}$ power
of the matrix be computed. One of the
disadvantages of this method is that it re-
quires the storage of approximately $n^3$

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bits of information. This shortcoming is
overcome however by the introduction of
a new recursion relation, which results
in the need for only about $3/n$ as much
memory storage as that required by the
usual Bingham Method.

If a matrix A is pseudo-multiplied times
itself a finite number of times, it is often
desirable to start with and obtain a ma-
trix whose coefficients are less than one
in absolute value. This can be done by
dividing each coefficient by an appropriate
scale factor. Using strict considerations
to compute the scale factor then, of course,
one can guarantee that relevant higher
powers have coefficients numerically less
then one, or if desired, that all powers,
after some selected one, round-off to zero.
But if one makes the assumption that the
coefficients are uniformly and independ-
ently distributed, and uses the theory of
the Edgeworth series, then a partial sum
of the Edgeworth series may be used to
ascertain a scale factor, although the ac-
curacy of the result must be measured by
the remainder term for which measure-
ment there exists as yet no practical me-
thod. If one uses three terms of the series
and the order of the matrix is one hundred,
then the calculated probability is 0.95 that
the square of a matrix will have coeffi-
cients which are less than one in absolute
value, if its coefficients are numerically
less than 0.4. This 0.4 should be com-
pared to the value 0.1 which is the value
obtained when strict considerations are
used.

A comparison of exact solutions and
pseudo-solutions of a linear equation is
based on the following definitions:

a) Any point $(X_j)$ for which one has exactly

$$\sum_{j=1}^{n} a_j X_j = b$$

is naturally called an exact solution.

b) Any point $\left[ X^P(j, k_j) \right]$ is called a pseudo-solution if

$$\sum_{j=1}^{n} a_j \times X^P(j, k_j) = b,$$

where the symbol x indicates that ordinary precision multiplication is to be used. Here $k_1, \ldots, k_n$ is an associated n-tuple defined below. c) If the coordinates of the point

$\left[ X^P(j, k_j) \right]$ also satisfy the condition

$$a_j \times X^P(j, k_j) = a_j X^P(j, k_j) \quad j = 1, 2, \ldots, n,$$

then $X^P(j, k_j)$ is denoted by $X^{PC}(j, k_j)$.

THEOREM 1. The points $\left[ X^{PC}(j, k_j) \right]$ exist and are pseudo-solutions which lie on the hyperplane of exact solutions. These points are located at the centers of n-dimensional rectangular parallelepipeds, called $\underline{n - topes}$, which contain all the pseudo-solutions.

The point $\left[ X^{PC}(j, 0) \right]$ is defined as the point $\left[ X^{PC}(j, k_j) \right]$ closest to the exact solution under consideration and is the center of the principal n-tope.

The general coordinate of any point on the hyperplane can be written

$$(1) \quad X_j = X^{PC}(j, 0) + k_j \, \beta^{-s} / |a_j|$$

$$+ \, m_j \, \beta^{-s} / 2 \, |a_j|$$

where the $k_j$ integers and the $m_j$ are any real numbers which satisfy the conditions:

$$\sum_{j=1}^{n} k_j \, a_j / |a_j| = 0,$$

$$\sum_{j=1}^{n} m_j \, a_j / |a_j| = 0.$$

THEOREM 2. An exact solution of a linear equation is a pseudo-solution if and only if

$$(2) \sum \left[ \text{positive} \frac{a_j m_j}{|a_j|} \right]_E = \sum \left[ \text{negative} \frac{a_j m_j}{|a_j|} \right]$$

where the $m_j$ are the same as in equation (1) and the symbol $\left[ x \right]_E$ means the closest even integer to x, except when x is equal to an $m_j$ which is an odd integer in which case the closest even integer is selected, if possible, so as to satisfy equation (2).

There is no loss of generality if the hyperplane (in n + 1 dimensions)

$$(3) \quad \sum_{i=1}^{n} x_i = x_{n+1}$$

is used in order to determine the distribution of the number of congruent subregions in a suitably defined generating region, the classification of such subregions according to whether they contain pseudo-solutions or not and the determination of the ratio of the volume of the subregions which contain pseudo-solutions to the total volume of the generating region.

THEOREM 3. Let n be odd in equation (3). Of the $2^n$ volumes in the $g^{th}$ position of the unit n-topes which make up the generating region, $(n + 1)$ contain pseudo-solutions. If the volume in the $g^{th}$ position of the unit (n-1)-tope is designated $V_{g, n}$, then the ratio of the volume of the subregion containing pseudo-solutions to the total volume of the generating region is

$$\frac{(n+1) \, V_{1, n+1} + \ldots + (n+1) \, V_{n, n+1}}{2^n \left[ V_{1, n+1} + V_{2, n+1} + \ldots + V_{n, n+1} \right]}.$$

By use of the fact that

$$V_{i, n+i} = V_{n+1-i, n+i} , \quad (i=1, 2, \ldots, \frac{n+1}{2} - 1),$$

the above ratio is shown to approach zero as the dimension becomes infinite.

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## CHEMICAL STUDIES ON VITAMIN B₁₂[1]

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An allocation of the thirteen nitrogen atoms of vitamin $B_{12a}$ was made by acid hydrolysis of the vitamin, Craig countercurrent distribution of the hydrolysate, and analyses of the various fractions for different types of nitrogen. It was found that five atoms of nitrogen were present in the hydrolysate as ammonia, two atoms as 5, 6-dimethylbenzimidazole, four atoms as the red acid fragment, and two atoms as 1-amino-2-propanol (or alternatively, one atom as 1-amino-2-propanol and one atom as a small unknown nitrogen compound). Of the five molecules of ammonia found, it was learned that three of these are readily formed during hydrolysis, but the remaining two are produced quite slowly. No carbon dioxide is produced during the acid hydrolysis of $B_{12a}$; some carbon dioxide, less than one mole, is produced in the hydrolysis of $B_{12}$, probably from the partial hydrolysis of the cyanide group.

The red fragment produced on acid hydrolysis of $B_{12a}$ is a mixture of cobalt-free and cobalt-containing materials. All attempts to purify the red acid fragment from either $B_{12}$ or $B_{12a}$ failed. Among the methods tried were countercurrent distribution, chromatography and ion-exchange. No single specie could be obtained in crystalline form, either as the free acid or as a metal salt. The information reported on the properties of the red acid fragment was thus obtained on a mixture of closely related materials.

The infrared spectra of the red acid fragment and vitamin $B_{12}$ were obtained. The differences in the spectra are in conformity with the hypothesis that acid amide groups are hydrolyzed during the acid treatment. The infrared spectrum of the red fragment suggests also that a cyclic structure, anhydride or lactone, is present. The infrared spectrum of the sodium salt of the red fragment is that expected of an ionized carboxylic acid. Treatment of the red acid fragment with acetic anhydride gives a product having the infrared spec-

trum typical of an acid anhydride.

The spectrum of the cyanide derivative of the red acid fragment is similar to that of the cyanide derivative of vitamin $B_{12}$.

Bromination of the red acid fragment results in a product with a markedly different spectrum (ultraviolet and visible) from that of the red fragment itself. The solubility properties of the product are also markedly different. Attempts at quantitative bromination of the red fragment gave uncertain values.

The fact that vitamin $B_{12}$ contains primary amide groups suggested a number of reactions which could conceivably be carried out that would possibly result in information as to the actual structure of the molecule, either per se, or by forming a compound which would be capable of crystallization, characterization and identification following hydrolysis.

A reaction of $B_{12}$ with alkaline hypochlorite was carried out. No ammonia was evolved during the reaction, thus precluding a substituted urea structure. No pure reaction product could be isolated from the reaction mixture, although the formation of an amorphous picrate indicated that amine formation had occurred.

Both mercuric oxide and mercuric acetate were found to react with $B_{12}$, presumably through the amide groups. The two products were not the same, however. Mercury to cobalt ratios determined on the mercuric acetate reaction product gave values approaching three.

The reaction of vitamin $B_{12}$ with acetic anhydride at reflux temperature yielded a purple product, somewhat soluble in ethylene chloride. The infrared spectrum of this material showed two absorption bands, $5.6 \mu$ and $5.7 \mu$ . These could be interpreted as resulting from either anhydride or cyclic imide structures. The ultraviolet and visible spectrum of the product did not resemble that of vitamin $B_{12}$.

During attempts to study the consumption of bromine by vitamins $B_{12}$ and $B_{12a}$, it was found that $B_{12a}$ was markedly active in the catalysis of the oxidation of iodide to iodine by air. $B_{12}$ was also active, but only at much higher concentrations.

The catalysis of the air oxidation if iodide to iodine was studied in detail; the rates of the reaction were measured at various concentrations of $B_{12a}$, iodide and sulfuric acid. It was possible to apply

classical enzyme theory to the system, in that dissociation constants of the complex (with either iodide or acid as "substrate") could be determined, and a plot of recip-

rocal velocity versus reciprocal "sub strate" (iodide or acid) resulted in straight line.

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## DETERMINATION OF MOISTURE IN SEEDS[1]

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Moisture content is the dominant factor in the establishment of grain grades and accurate methods for its estimation are essential. There is evidence, unfortunately, that the available moisture tests are not uniformly reliable under all conditions. We have attempted, therefore, to study moisture content of two locally important seeds from the basic standpoints of seed physiology and moisture bonding as these affect estimates of total moisture content.

The total water content of whole seeds of maize and soybeans was determined by drying to constant weight in an air oven at 100° C., a vacuum oven at 70° C., or in a vacuum desiccator at 25° C. Similar moisture percentages were indicated by drying at 100° C. for 12 days or in the vacuum oven for 23 days. Ninety-five per cent of the total moisture loss was obtained in the first two days at 100° C., and the first six days at 70° C. Seeds in the vacuum dessicator were still losing weight slowly after 60 days, and still contained about 3 per cent moisture on a dry weight basis. This moisture is considered to be a minimum estimate of bound water in the seeds. Drying in a dessicator did not affect viability of the seeds.

When constant weight at 100° C. was taken as a measure of true moisture content, the Brown-Duvel moisture test gave reasonably concordant results, while the Tag-Heppenstall conduction method was

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consistently low, indicating standardiza tion on a less rigorous drying procedure Any of the three methods could have bee expected to give a satisfactory estimate o moisture content with proper manipulation When, however, the moistened seeds wer frozen at -23° C. before testing, the Tag Heppenstall readings were about 1 per cer high on all seeds whose permeability ha been increased by freezing injury.

Drying tests were carried out on cor in a 100° C. air oven for 24 hours. A temperatures of 100°, 110°, 120° and 130 C., moisture loss curves formed a set o hyperbolas which tended to become paral lel. Such curves indicate that the specif free energy of moisture at the surface o the seeds decreased with decreasing mois ture content. Specific free energy at th surface may be considered to be affecte by adsorption bonds, which reduce the va por pressure of water, and by permeabilit factors which control the rate of move ment of moisture to the surface.

Moisture loss at varying times was a linear function of temperature. Ruptures of corn seeds with 45 per cent of moisture heated to 130° C. increased permeability, thus causing a deviation in this relation-ship.

The moisture content of seeds varie with the relative humidity of the environ-ment under both laboratory and commer-cial conditions. Experiments on weigh changes in corn and soybean seeds storec at varying relative humidities gave an op-portunity to study the forces acting in the distribution of moisture between atmos-phere and seeds. Rate of water loss o adsorption was greater in soybeans thai corn, as measured by the diffusion coef-ficient, and water was held more loosely by soybeans than corn, as determined from free energy calculations.

# THE HISTOLOGY OF THE BUD GRAFT UNION IN ROSES[1]

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The growing importance of stock-scion compatibility in roses has called attention to the possible relationship between the histology of the bud union and relative compatibility. This investigation was undertaken to determine the course of histological events in the healing of the bud graft of rose, and thereby, provide basic information for further studies in relation to incompatibility.

Six lots, each consisting of 25 seedlings of Rosa multiflora, were budded with R. multiflora, Welch strain, on each of three successive mornings beginning on July 15. One random sample was taken daily from each lot of budded plants for 14 days beginning the day of budding. The samples were killed in a Nawaschin-type formula and processed for sectioning in paraffin. In order to compare bud grafts made in root tissue with those made in stem tissue, rooted cuttings of R. odorata, 22449, were budded with R. odorata, 22449, scions on October 10, 11, and 12, 1952. The same procedures of budding, processing, and sectioning described for the bud grafts made in seedling understocks were followed. Samples were taken at 48-hour intervals.

In the processes of making the incision in the stock and the removal of the scion from the bud stick, the cambium and young cambial derivatives were found to be destroyed in the areas involved.

Within two days following budding, a plate of dead, dry, necrotic tissue forms over the injured surfaces of the stock, scion, and bark flaps. The necrotic plate

is ruptured by callus strands derived from proliferated terminal cells of broken rays. The callus strands derived from tissues of the stock and scion coalesce by the fifth day. The callus is produced by cambial derivatives which are regarded to be immature secondary xylem and phloem. These secondary cells on the injured surfaces of the stock and scion between the rays undergo repeated tangential division and form arcs of stratified callus which do not rupture the necrotic plate behind which they develop.

Between the third and fifth day after budding, spongy callus cells adjacent to uninjured stock cambium undergo repeated tangential and radial division and form a short arc of bridging cambium, which connects the intact stock cambium with cambiform tissue that had differentiated simultaneously from cells of the stratified callus. This cambiform tissue elongates in the direction of the scion by radial division at the edges. By the tenth day division at the edges. By the tenth day an uninterrupted cambiform layer connects the intact stock cambium on either side of the scion by bridging cambium and extends across the face of the stock.

Between the tenth and fourteenth days, arcs of cambiform tissue differentiate in scion tissue, elongate by radial division at the edges, and join with arcs of cambiform tissue derived from stock callus. Simultaneously with the development of cambiform arcs, the cambium of the bud elongates by radial division at the edges, usually following the inner surface of the scion. The bud cambium unites with cambiform tissue extending out of stock callus through the zone of merged callus, and, thereby, forms an uninterrupted ring of cambium through the stock and scion. Union of cambial elements of stock and scion occurs between the tenth and fourteenth day.

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## GENERALIZATIONS OF CONTINUITY₁

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A generalization of continuity is developed. This generalization includes several known generalizations as special cases.

Let X be a Hausdorff space in which each neighborhood is inexhaustible (a set of Baire's second category), and let $[N]$ denote the system of neighborhoods in X. Let Y be a regular separable Hausdorff space metrized by $\rho$, and let $[M]$ denote the system of neighborhoods in Y. Denote the complement with respect to X of a set S by $S^{\sim}$, and denote the closure of S by cS.

In the following definitions and theorems, $\lambda$ is a set property defined for subsets of X, S is a set in X, f is a function on X into Y, and $\xi$ is a point in X.

DEFINITION 1. a. The point $\xi$ is said to be a point of $\lambda$ f-approach by S if, for every $N(\xi)$ and for every $M(f(\xi))$, $N(\xi)SE$ $[x:f(x) \in M(f(\xi))]$ has property $\lambda$.

b. The point is said to be a point of $k \lambda$ f-approach (concentrated $\lambda$ f-approach) by $\underline{S}$, if, for every $M(f(\xi))$, there exists an $N(\xi)$ such that, for every N contained in $N(\xi)$, $[NSE \ x:f(x) \in M(f(\xi))]$ has property $\lambda$

c. The point $\xi$ is said to be a point of $w \lambda$ f-approach (weak $\lambda$ f-approach) by $\underline{S}$ if, for every $N(\xi)$ and for every positive number $\varepsilon$, there exists a point $\eta$ such that $N(\xi)SE [x:\rho(f(x),\eta)<\varepsilon ]$ has property $\lambda$.

DEFINITION 2. a. The function f is said to be neighborly (1) at $\xi$ if $\lambda$ is the property that a set contains a neighborhood and if $\xi$ is a point of $\lambda$ f-approach by X. If f is neighborly at each point of S, f is said to be neighborly on S.

b. The function f is said to be cliquish (2) at $\xi$ if $\lambda$ is the property that a set contains a neighborhood and if $\xi$ is a point of $w \lambda$ f-approach by X. If f is cliquish at each point of S, f is said to be cliquish on S.

DEFINITION 3. a. The property $\lambda$ is an ascending set property if, for every set S which has property $\lambda$ and for every set A in X, the set $(S + A)$ has property $\lambda$.

b. The property is locally characterizing if, for every set $\overline{S}$ which has property $\lambda$ and for every N such that NS has

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property $\lambda$, there exists an $N_1$ containe in N such that $N_1S$ has property $\lambda$ and $N_1(S^{\sim})$ does not have property $\lambda$.

If $\lambda$ is the property that a set contains a neighborhood of $\xi$, and if $\xi$ is a point o. $\lambda$ f-approach by X, then f is continuous a $\xi$. Particular generalizations of continuity are obtained if $\lambda$ is one of the following properties: residual on a neighborhood inexhaustible, contains a dense-in-itsel: subset, has positive outer measure, nondenumerable, infinite, contains a neighborhood.

The following theorems are typical results of the thesis.

THEOREM 1. The set of points of $w \lambda$ f-approach by S is closed.

A particular consequence of this theorem is the result that if a function is cliquish on a dense set in its domain of definition, then it is cliquish at every point of its domain of definition.

In the following theorems, $\lambda$ is assumed to be an ascending set property.

THEOREM 2. The set of points of $\lambda$ f-approach by S which are not points of $k \lambda$ f-approach by S is exhaustible.

In case $\lambda$ is the property that a set is inexhaustible, Theorem 2 reduces to a result of Blumberg (3).

THEOREM 3. If the sequence of functions $[f_n(x)]$ converges uniformly to $F(x)$ on X, and if there exists a point $\xi$ such that for each n, $\xi$ is a point of $\lambda$ $f_n$-approach by S, then $\xi$ is a point of $\lambda$ F-approach by S.

In particular, Theorem 3 yields the known results that the uniform limit of a sequence of continuous (neighborly) functions is continuous (neighborly).

THEOREM 4. If X is a metric space, if f is bounded at $\xi$, and if $\xi$ is a point of $w \lambda$ f-approach by S, then f may be redefined at $\xi$ in such a manner that, for the resulting function $f_1$, $\xi$ is a point of $\lambda$ $f_1$-approach by S.

In the remaining theorems, $\lambda$ is assumed to be both ascending and locally characterizing.

THEOREM 5. If each element of S is a point of $\lambda$ f-approach by S, and if $\xi$ is a point of $\lambda$ f-approach by S, then, for every $M(f(\xi))$ and for every $N(\xi)$, there exists an N contained in $N(\xi)$ such that, for every x in NS, $f(x) \in M(f(\xi))$.

THEOREM 6. If $R^{\sim}$ is exhaustible, if the sequence of functions $[f_n(x)]$ converges to $F(x)$ on X, and if, for every n, each x

R is a point of $\lambda$ $f_n$-approach by R, then
$(x)$ is continuous over R with respect to
$t$, except on an exhaustible set.

In particular, Theorem 6 yields the
known results that the limit of a sequence
f continuous (neighborly) functions is
continuous except on an exhaustible set.

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# INTERRELATIONS OF MILK PRODUCTION AND BREEDING EFFICIENCY IN DAIRY COWS[1]

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Three criteria of breeding efficiency
were studied to find their relationship with
each other and with production, and to
learn their repeatability and heritability.
These three criteria were days to first
estrus, days to conception and services to
conception. It was also possible to study
how these three criteria were affected by
some other variables such as age, season
of year, differences between herds, etc.

The data were 1646 lactation periods of
763 cows in either the Holstein herd at
Iowa State College or the Iowa State Board
of Control herd at Cherokee from January
of 1940 to August of 1951.

Differences between the herds were found
in days to first estrus and in days to con-
ception, but not in services to conception.
In days to first estrus the modal class was
31-50 days in both herds with means of 55
and 71 days and standard deviations of 30
and 50 days in herds 1 and 2 respectively.
For number of days to conception the
means were 28 and 42 with standard devia-
tions of 28 and 76. The mean number of
services to conception was 1.8 in herd 1
and 1.7 in herd 2. The corresponding
standard deviations were .4 and .3.

In both herds the age distributions were
highly skewed in the direction of the young-
er animals. Most heifers in the Iowa

State College herd calved for the first
time as two year olds, but many heifers
in the Cherokee herd did not freshen until
three years old. Age differences accoun-
ted for less than two per cent of the var-
iance in these criteria of breeding effi-
ciency. Parities coincided closely with
age, of course.

Yearly changes accounted for less than
four per cent of the variance in all three
criteria in both herds, except that in herd
2 approximately 15 per cent of the variance
in days to first estrus seemed due to year-
ly effects. This seemed due, in part at
least, to changes in labor and manage-
ment practices during the period studied.

When the records were grouped accord-
ing to each cow's previous production, lit-
tle relationship was observed. When the
same variables were grouped by current
production, differences were found in days
to conception and in services to concep-
tion. Much of this was probably automatic
in that delaying conception lessens the ef-
fect of recurrent pregnancy in hampering
the cow's opportunity to make a good re-
cord.

Using 444 records in herd 1, 487 in
herd 2, correlations were computed be-
tween the three variables and between
them and preceding production. These
correlations were small and statistically
insignificant except that the correlation
between days to conception and services
to conception was +.84. That this corre-
lation is so high is largely automatic, be-
cause the two variables are to a consider-
able extent measures of the same thing.

The corresponding correlations between
the three variables and current production
were calculated on 759 records from herd

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1, and 780 records from herd 2. Again the correlation between days to conception and services to conception was high, $r = +.81$. Current production was correlated, $+.151$ and $+.153$, with days to conception and with services to conception, both correlations being statistically significant at the one per cent level. Presumably much of this reflects the effects of early or late recurrence of pregnancy on production late in the lactation.

Multiple regression preceding production on the three variables showed little relationship. $R^2$ was .005 for herd 1 and .017 for herd 2. Multiple regression of current production on the same variables revealed essentially the same picture except that the partial regression of $5.1+1.7$, in herd 2, indicated that for each additional service required for conception an extra 510 pounds of milk could be expected in that lactation. $R^2$ was .027 in herd 1 and .036 in herd 2.

Repeatabilities were estimated from 764 records on 321 cows in herd 1 and from 782 records on 294 cows in herd 2. Repeatability of days to first estrus was .15 in herd 1, and .27 in herd 2. The aver-

age repeatabilities of days to concepti and services to conception were .05 a .06, respectively. Repeatability of the three variables is probably positive b very low.

Heritabilities were estimated by doub ling the intra-sire regression of daughte on dams. 243 daughter-dam pairs wei available in herd 1, and 191 in herd 2 Four of the six very small values obtain were negative, a result theoretically in possible except for sampling errors. Sin the sampling errors could be large in th amount of data, the only reasonable con clusion is that the heritability of the thre measures of breeding efficiency is not fz from zero.

If heritability and repeatability of tl three variables really are as low as tl estimates obtained from this investigatior selection for breeding efficiency in thes herds cannot be very effective. Givin attention to breeding performance will de crease the progress that could otherwis be made in selecting more strongly foi other traits of economic importance foi which repeatability and heritability esti mates are considerably higher.

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## UNIDENTIFIED CHICK GROWTH FACTORS IN UNSATURATED FATS[1]

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Sources of unidentified growth factors for chicks have been studied using semi-purified diets.

Crude or refined corn oil, wheat germ oil, soybean oil, and cottonseed oil were sources of unidentified growth factors which increased chick weight at four weeks from 10 to 30 per cent. Factors in fat were not required for livability of chicks or for the prevention of dermatitis. The requirement of the chick for the growth factors in these vegetable oils was satisfied by the addition of from one to two per cent of any one of these oils to the basal diet. The four vegetable oils contained similar quantities of the unidentified factors. The saponifiable fraction of cottonseed oil possessed the major portion of

its growth factors, but the nonsaponifiable fraction was also growth - promoting. Commercially hydrogenated soybean oil, in the form of oleomargarine, was devoid of much of the growth factor activity possessed by soybean oil.

Growth responses to the 60 per cent lineoleic acid concentrate were inconsistent. This may have been due to its decided tendency to become rancid. One and a half per cent of this concentrate in the diet was superior to lower levels for increasing growth. Lower levels of the concentrate were adequate when they were fed in combination with low levels of wheat germ oil.

An oleic acid concentrate prepared from beef tallow was consistently slightly superior as a source of growth factors to individual supplements of vegetable oils or the linoleic acid concentrate. The optimum level of feeding the oleic acid concentrate was one per cent. The addition of a vegetable oil to a diet containing one per cent of the oleic acid concentrate did

ncistimulate growth.

rowth response from feeding pure me-
(ha! oleate, methyl linoleate and methyl
linenate was inconsistent and rather
pull. Stearic acid was not growth-
promoting for the chick at either the one
ocowo per cent level.

rheunidentified factors in fats and fatty
acd concentrates were distinct from the
giwth factors shown by other workers to
bresent in fat-free Liver L and Biopar
C The factors in Liver L and Biopar C
irceased growth only slightly.

ork liver residue, which contains 18.8
pi cent arachidonic acid of its total fatty
ads, was a fair source of growth factors

which were shown to be ether-soluble.

Yellow corn increased growth and feed
efficiency, but this study did not establish
whether this was entirely attributable to
factors in the ether-soluble portion of the
corn.

Butter and oleomargarine were approxi-
mately equal as fat supplements for chicks,
but were inferior to more unsaturated fats.

Carcass protein was increased and car-
cass fat was reduced by the addition of
unidentified growth factors to the "fat-
free" diet. No hormonal activity, as
measured by weight of testes, could be
demonstrated for the various sources of
unidentified growth factors.

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## ADAPTATION OF THE FARM FIRM IN WESTERN KANSAS TO CONDITIONS OF UNCERTAINTY[1]

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the objective of this thesis was to ex-
mine methods of adaption by the farm
im to the conditions of uncertainty that
ist in Western Kansas. Methods that
rve been developed in economic logic
ere tested empirically. Primary data
ere available from the Colby and Gar-
jn City Kansas Agricultural Experiment
ations.

nThe precautions that have been devel-
ped in the literature of economics which
ay be taken by the firm under conditions
of uncertainty are diversification, liquid-
y, and flexibility. These methods were
xamined from a theoretical as well as
rom an empirical standpoint. In addi-
on, the effect of the proximity of the
ousehold to the firm and the variability
f the management function were treated.
A deductive examination determined
hat the effect of diversification on varia-
ility will depend upon the relative varia-
ility of the added and the existing enter-
prises and the degree of association
among the enterprises. Yields and prices
are the relevant variables that determine
he effect of the addition of enterprises.

Flexibility is a precaution which may
take the following forms: output, product,

and contract. All forms were examined
from a deductive standpoint and were
thought to have application to the problem
of decision making under conditions of
uncertainty.

Liquidity, which permits assets to be
converted into cash easily, is a precau-
tion available to the firm. It is a safety
device which permits unfavorable pro-
duction conditions to be met. The logic
of flexibility and liquidity are similar;
the distinction is that the former applies
to production while the latter relates to
exchange.

Yields from the Garden City Station in-
dicated that the variability of wheat or
milo alone could be reduced by some
combination of the two. Kafir forage had
lower variability than did any of the grain
crops. This suggested the possibility of
a livestock enterprise.

Price relationships were studied prior
to the calculation of gross income from
the various enterprises. The degree of
association was quite high among various
prices indicating that the possibilities of
diversification in the reduction of varia-
bility would not be great.

When price and yield data were com-
bined for the Garden City Station, it was
found that either the addition of milo or
the addition of a cattle enterprise to the
production of wheat would reduce varia-
bility.

The variability of the physical produc-
tion of wheat was not reduced by the ad-
dition of any other grain crop at the Col-

l a. Chairman of Committee, Earl O. Heady,
     Dept. of Economics and Sociology.
  b. Doctoral Thesis No. 1333. Submitted
     August 16, 1952.
2 a. B.S. Kansas State College, Manhattan,
     Kansas, 1948.
     M.S. Ibid., 1950.
  b. Graduate Assistant, Agricultural
     Experiment Station.

by Station. Sorghum forage production was a more stable crop than wheat. This fact suggested that a forage consuming livestock enterprise might stabilize returns from wheat alone. Although variability was not decreased, it was found that a wheat-milo combination decreased the number of years that there were complete crop failures.

An analysis of gross income data of various enterprise combinations indicated that milo and, or, cattle when added to wheat would decrease variability. It was concluded that while the reduction in variability was not large, the reduction may occur in strategic years since the number of years in which there were complete failures was reduced by a combination of enterprises.

The possibilities of area diversification were examined. Data for the Colby and Garden City Experiment Stations were combined. The reduction in variabilit was not large but was of the same gener al magnitude as the reduction due to pro duct diversification.

Soil moisture tests at seeding time a the Colby Station were used as a basi for making decisions for seeding or fal lowing for a hypothetical flexible organi zation. The net returns from this or ganization were compared with the re turns from a continuous wheat organiza tion and an alternate crop and fallow or ganization. It was found that the contin uous wheat organization was inferior to the other organizations both in terms of variability of income and also in terms of net income. The flexible system was superior to the alternate crop and fallow system in terms of net income but was inferior in terms of variability of income.

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## PHOTOSYNTHESIS IN THE POTATO, SOLANUM TUBEROSUM L.[1]

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The air-stream method was used to measure the rate of $CO_2$ absorption by potato leaves during three seasons under field conditions. Four absorption units were attached to leaf chambers with enclosed leaves; two units were used as checks. The effects of temperature, light, $CO_2$ supply, and leaf hydration on the rate of photosynthesis were of primary concern.

Large variations in the rate of $CO_2$ absorption by potato leaves were observed, both with paired leaves on the same plant and on different plants. Due to this paired variation, large populations of observations were required to determine the significance of observed relationships.

Changes in temperature did not influence significantly the rate of $CO_2$ absorption between $21°$ and $42°$ C. It appears likely that the $Q_{10}$ for photosynthesis of potato leaves under field conditions is near 1.0; thus the dark or enzymatic reactions ($Q_{10}$ 2.0 or more) must not be limiting. Since light saturation of the photosynthetic process was reached at approximately 3000 f.c. the light intensity ($Q_{10}$ of photochemical reactions 1.0), a diffusion process, probably gaseous or liquid diffusion of $CO_2$ to the sites of photosynthesis ($Q_{10}$ 1.0 to 1.4), must be limiting under field conditions.

Twice normal $CO_2$ (0.06% by volume) and five times normal $CO_2$ (9.15%) in the air-streams resulted in linear increases in $CO_2$ absorption by potato leaves. Doubling the apparent assimilation required an increase of the $CO_2$ concentration by a factor of 2.2 to 2.6. Close correlation between light intensity and $CO_2$ absorption was found below 3000 f.c. with normal $CO_2$ in the air-stream, below 4200 f.c. with twice normal $CO_2$, and below 5200 f.c. with five times normal $CO_2$. These facts indicate that at high light intensities the quantity of $CO_2$ diffusing into the cells of a potato leaf limits their rate of photosynthesis.

The family of lines formed when rate of $CO_2$ absorption was plotted against light intensity (below saturation) increased in slope as the $CO_2$ concentration of the air-stream was increased. Therefore, photosynthesis may be limited by both $CO_2$ diffusion into leaf cells and light below saturation intensities.

Badly wilted potato leaves usually ab-

1 a. Chairman of Committee, W. E. Loomis, Dept. of Botany and Plant Pathology.
   b. Doctoral Thesis No. 1308. Submitted July 10, 1952.
2 a. B.S. University of Nebraska, Lincoln, Nebr., 1943.
   M.S. Ibid., 1950.

 added 1/10 to 1/2 as much $CO_2$ as turgid leaves. Turgidity of permanently wilted leaves was regained within 1 to 3 hours after watering, while their rate of $CO_2$ absorption returned to normal much more slowly. Physico-chemical changes in the protoplasm may be responsible for the delayed recovery. A gradual decline in the general level of $CO_2$ absorption was observed as the season progressed and the plants increased in age.

On bright days the rate of $CO_2$ absorption of potato leaves increased rapidly as light intensity increased in the early morning hours, reaching a maximum for most days between 7:00 and 9:00 a.m. This peak was followed by a gradual decline during midday and a rapid drop to zero as light diminished in the late afternoon. Such a diurnal curve is typical of many species of plants.

The mean rate of $CO_2$ absorption by leaves of four different potato varieties did not differ significantly. Variations between paired leaves with the air-stream method are too large to allow measuring small varietal differences, if they exist.

The $CO_2$ content of the air around potato plants, as determined by the check towers during the day, averaged about 0.48 mg. per liter; considerable less than the generally quoted mean of 0.59 mg. per liter. Equilibrium between photosynthesis and respiration is generally assumed to be reached at about 0.20 mg. per liter for land plants, depending on the temperature and other factors. Thus only some 0.28 mg. of $CO_2$ per liter of air was more or less readily available for photosynthesis by potato leaves in western Nebraska.

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## ON-SPORULATING OBLIGATELY ANAEROBIC BACTERIA IN DAIRY PRODUCTS[1]

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Non-sporulating anaerobic bacteria have been reported in the literature as being associated with dairy products. This study was made to determine the relative number, types and importance of non-sporulating anaerobes which might be found in dairy products. The products examined were raw milk, raw cream, Cheddar cheese and rumen liquid. When raw milk and cream were used as the source material, the samples were enriched by placing at room temperature until they coagulated, after which deep-agar shake tubes and deep-agar plates with an overlay were made of the proper dilutions. The medium that proved to be most successful for anaerobic isolation was a trypticase-soy-glucose agar containing 10 per cent V-8 juice, 0.05 per cent cysteine hydrochloride and 0.05 per cent Tween 80. The medium was adjusted to pH 6.3-6.5, using phosphate buffer. The shake tubes or

plates made of the diluted samples were incubated at 35-37° C. under anaerobic conditions for 7-10 days. Anaerobic conditions were established by removal of residual oxygen with a palladinized asbestos catalyst, 90 per cent hydrogen and 10 per cent carbon dioxide being present in the incubation chamber. The colonies which were small or were winged-shaped were picked into tubes of solid medium. Those cultures showing growth in the bottom of the tube and not in the aerobic zone 8-10 mm. from the surface of the agar were selected as being anaerobes. The use of a semi-solid medium containing 0.13 per cent agar was very successful in carrying anaerobic cultures in the shake tubes. In this study a total of 4,202 colonies were picked from 18 milk samples, 33 cream samples, 13 cheese samples, and three rumen-liquid samples. From the total colonies picked, only 239 (approximately 6 per cent) proved to be non-sporulating anaerobes.

One paramount problem encountered in the isolation of anaerobes was the relatively large number of facultative types usually found in dairy products. Several methods were tested to either selectively prevent the growth of the facultative types or to find some distinctive characteristic of the obligate anaerobes that would be

apparent during the course of the isolation procedure; however, none proved to be successful.

The 239 anaerobes isolated were divided into four groups on the basis of morphology, biochemical tests and fermentation ability. Group 1 consisted of 115 isolates from milk, cream, cheese, and rumen liquid. These cultures were gram-positive, nonmotile, short rods $0.5-0.7 \times 0.7-1.3$ $\mu$, which formed lens or winged sub-surface colonies and circular, translucent, convex and smooth surface colonies. Group I cultures reduced litmus milk and coagulated milk with a pH of 5.7. The cultures grew well at 21, 30 and 35-37° C., while only a few also grew at 45 and 10° C. Generally they did not survive 60° C. for 10 minutes. Group I cultures were catalase-positive, reduced nitrates, produced indole, were proteolytic, produced propionic and acetic acids and utilized lactates. They fermented fructose, galactose, glucose, mannose, mannitol, and sorbitol. Some cultures were lipolytic and a few were hemolytic on bovine blood. All cultures tested were hemolytic on human and rabbit blood. Group I cultures grew well in Collins' and Delwiche's media when modified by addition of tryptophane and reticulogen, respectively. The cultures produced bitter and rancid flavors in milk. Group I cultures resemble Bacteroides pseudoramosus (Eggerth) ATCC No. 8489. Because the genus Bacteroides has been reserved for gram-negative organisms, it was proposed that cultures of Group I be considered closely related to Ramibacterium pseudoramosum (Prévot and that this genus be taken out of the genus Lactobacillus and placed in the family Lactobacteriaceae close to the genus Propionibacterium.

Group II consisted of 88 isolates from milk and cream. The cells of Group II cultures were gram-positive, nonmotile rods $0.4-0.6 \times 0.8-1.6 \mu$, which formed lens shape sub-surface colonies and punctiform, translucent, convex and smooth surface colonies. These cultures reduced litmus milk and coagulated milk with a pH of approximately 4.0 and a titratable acidity of 1.7-1.9 per cent. The cultures grew well at 10, 21, 30 and 35-37° C., but not at 45 and 5° C. Generally they survived 60° C. for 10 minutes, while only a few cultures survived for 20 and 30 minutes. Group II cultures were catalase-negative, produced acetic and inactive lactic acid and fermented arabinose, cellobiose, fructose, galactose, glucose, lactose, maltose, mannose, raffinose, sucrose, and salicin. A few cultures also

fermented inulin, xylose, mannitol, a sorbitol. Group II cultures grew well Collins' and Delwiche's media when mod fied by addition of tryptophane and retic logen, respectively. When inoculated in milk, the cultures produced a clean ac flavor. In many instances, Group II cu tures resemble members of the gen Lactobacillus and more specifically bifidus types I and II described by Rettge Because of several uncommon characte istics, cultures of Group II were consi ered different from these types, and was proposed that they be placed in t genus as Lactobacillus anaerobius, spe nov.

Group III consisted of three isolate from one sample of cream. These cul tures were gram-positive, nonmotile short rods $0.5-0.7 \times 0.7-1.3 \mu$, whicl formed lens shape sub-surface colonie and circular, translucent, convex ar smooth surface colonies. Group III cu tures did not reduce litmus milk or coagu late milk, but after 7 days the pH was 5.7 The cultures grew well at 10, 21, 30 ar 35-37° C., but not at 45 or 5° C. The survived 60° C. for 30 minutes. Grou III cultures were catalase-positive, re duced nitrates, produced propionic an acetic acid, utilized lactates and fermente arabinose, fructose, galactose, glucose maltose, mannose, mannitol, sorbitol an salicin. Group III cultures grew well ir Collins' and Delwiche's media withou supplementation. Because of the resem blance of Group III cultures to Group cultures, it was proposed that they be placed in the genus Ramibacterium (Pré vot). The proposed name for this specie is Ramibacterium lacticum, spec. nov.

Group IV consisted of one isolate fron a milk sample. The cells of this culture were $0.4-0.6 \times 0.7-1.0 \mu$, which formed lens shape sub-surface colonies and punc tiform, translucent, convex and smootl surface colonies. This culture did not re duce litmus milk or coagulate milk an the titratable acidity after incubation fo 7 days was 0.27 per cent. The culture grew well at 21, 30, 35-37 and 45° C., bu not at 5 or 10° C. It did not survive 60 C. for 10 minutes. This culture was cata lase-negative, reduced nitrates, produce hydrogen sulfide and acetic acid, utilize lactates, but did not ferment any of the carbohydrate compounds tested in th study. Group IV culture grew well i Collins' and Delwiche's media withou supplementation. When inoculated into milk, the typical hydrogen sulfide odor and flavor was produced. In many res pects, the Group IV culture resemble

; gram-negative <u>Bacteroides</u> <u>siccus</u>
scribed by Eggerth.

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## ADSORPTION OF ALIPHATIC ALCOHOLS AND ACIDS FROM BINARY AQUEOUS SOLUTION BY NON-POROUS CARBONS[1]

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Department of Chemistry

The adsorption of the normal aliphatic alcohols and the normal fatty acids containing two to seven carbon atoms from their aqueous solutions on three different non-porous carbon adsorbents has been investigated. The purpose of this investigation was to establish experimentally the effects of variation of the dilute activity, the chain length of the sorbate molecules, the type of functional group contained in the molecule, and the nature of the carbon surface upon the amount of solute adsorbed from solution, and in this manner to contribute toward the possible development of a satisfactory general theory of solution adsorption. Non-porous adsorbents were used to eliminate capillary condensation effects which arise with charcoals and other porous materials, and which obscure the effects of any adsorption forces actually existent at the solution-solid interface. In this investigation, absolute solute activity extended in every case from zero to at least 0.88. The amount of solute adsorbed was determined by interferometric measurements of the change in solution concentration upon exposure to the solid adsorbent samples.

Adsorption from the aqueous phases of those of the alcohols and acids which are not totally miscible with water invariably showed a rapid rise in the amount of adsorption as the solution concentration approached the saturation value. This rise reflects the dependency of the adsorption upon the work required to remove the sorbate from solution, and the adsorption values reached in these measurements demonstrate that the adsorption necessarily must be multimolecular.

For a given adsorbent the surface excesses of the immiscible acids depended only on the absolute activity of the acid in the solution over the entire activity range. The miscible acids followed the same surface-excess versus activity curve for ranges which were more extensive the higher the position in the homologous series. A similar generalization applies approximately to the alcohols; deviations were significantly greater with the alcohols than with the acids, and appear to be systematic. In both homologous series, the individual isotherms varied only five to ten per cent for all the different members of the series in the activity range $0.005 \leqslant a \leqslant 0.10$. Traube's rule has been shown to be a necessary consequence of this behavior.

For the miscible systems, the adsorbents Graphon and DAG-1 showed positive adsorption of the organic component over the entire concentration range; the adsorbent Spheron-6 gave S-shaped isotherms, with negative adsorption of the organic component at high concentrations. Correspondingly, measurements of the adsorption of water from the organic phases of the immiscible alcohols and acids showed no preferential adsorption of water at any concentration by Graphon nor DAG-1, while Spheron-6 did show a definite adsorption of water in all cases. The water adsorption isotherms on Spheron-6 were of the Langmuir type. Apparently a portion of the surface of Spheron-6 consists of sites, perhaps particular types of oxygen complexes, which possess specific affinity for water molecules. These sites are removed in the process of graphitization of the Spheron-6 carbon black.

While the varying specific surface characteristics of the three carbon adsorbents markedly affect the adsorption of water from binary solutions of low water concentration, these characteristics have little effect on the adsorption of organic solutes from dilute aqueous solution. The effects appear to be significant but

are small compared with the absolute activity factor.

A mean isotherm for the immiscible alcohols on a given adsorbent was identical with the corresponding isotherm for the acids. This lack of dependence on functional group suggests that any specific interaction which may exist between organic adsorbate and carbon surface involves primarily the alkyl group rather than the functional group, and again emphasizes the relative importance of absolute solute activity as the most important factor in determining adsorption from solution.

Attempts to compute thickness of adsorbed layers from solution adsorption data alone have proved unsuccessful. For such computations, independent related data giving information such as actual potential functions or vapor phase ad-

sorption would be required.

Solubilities of water in the alcohols and acids with which water is not miscible in all proportions have been determined at 25° C., as have also the solubilities of these alcohols and acids in water. Some of these are new measurements; the others have been independently determined, and their values compared with values published in the literature.

The adsorption of alcohols and acids from aqueous solution on non-porous carbons has been found to be a rapid process. Equilibrium was established in less than two minutes. There was no indication of a further rise in adsorption after this time.

Twenty-two tables of experimental data and twelve graphs are given in support of the above observations and conclusions.

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## BIOLOGY AND CONTROL OF THE WOOLLY APPLE APHID IN IOWA NURSERIES[1]

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Department of Zoology and Entomology

The woolly apple aphid Eriosoma lanigerum (Hausmann) has been a major pest of nursery grown apple trees for many years. This is especially true in the vicinity of Shenandoah, Iowa, where the largest and most concentrated nursery industries in the United States are located. At the request of the industry and with their active support, the studies were begun in the fall of 1949 and continued through 1952.

The studies were divided into two parts. The first part consisted of a re-examination of the life history of the insect; the second part was devoted to methods of control.

From observations it was found that the life history of the woolly apple aphid in Iowa followed, in general, that outlined for other areas of the eastern United States. The earliest dates of observation of the stem mother form on American elm were April 10, 1950; April 20, 1951; and April 7, 1952. The average number of progeny deposited by 16 stem mothers under labo-

ratory conditions was 67.75. Dissections revealed this average represented approximately one-half of the embryos which developed within the stem mothers.

Under laboratory conditions, second generation aphids moulted four times and reached reproductive maturity at from eight to eleven days of age.

The earliest dates of observation of spring migrants were May 29, 1950; May 31, 1951; and May 20, 1952. The latest dates of observation of spring migrants were July 1, 1950; June 28, 1951; and August 28, 1952. The average number of spring migrants from 15 cages rosettes was 1081,13 for 1950, while the average for nine rosettes in 1952 was 589.67. The average number of embryos obtained by dissecting 20 spring migrants was 5.87. Apple trees were infested in the laboratory and in the field by nymphs deposited by spring migrants.

Root form aphids, cages in "Buckeye" seamless tin boxes of two ounce capacity, on the roots of apple trees were observed from June 19, 1952, to October 30, 1952. As many as eight generations were produced and the length of generations, based on time interval between birth and reproductive maturity, varied from eight to 29 days. The number of moults for each individual in general varied from four to

; however, two aphids moulted six t:es each.

t was demonstrated that seedling apples ild be infested by budding them with :did-infested buds.

The first fall migrants were observed ltober 10, 1949; September 27, 1951; 1 September 23, 1953. Fall migrants veloping under field conditions contained c forms in the ratio of 1:1, while mi-ints developing under greenhouse condi-ens contained a relatively large number female embryos. In some instances all e sexuals of a migrant were females. e average number of sexuals obtained dissecting 20 migrants collected in the ld was 8.9.

Two experiments demonstrated that only small percentage of seedling apple trees came infested with root form aphids ring the first growing season in the nur-ry row. In one experiment 2.69 per nt of the trees were root infested the st year and 51.86 per cent were infested the end of the second growing season. l the second experiment not a single tree is infested at the end of the first growing ason.

Tri-6 WE-10 (10 per cent gamma iso-er) at levels of 1 and 2 pounds gamma omer per acre and chlordane at levels of and 30 pounds per acre, applied as rays, were ineffective in controlling the pot form aphids on heavily infested two-ear budded apple trees. The chemicals ere also ineffective when an additional ray was applied during the third grow-g season.

Treatments using gamma isomer of ben-ne hexachloride at levels of 0.25, 0.5, ad 1 pound, when applied in 200 gallons finished spray per acre, were ineffec-ve in controlling the root form aphids on ne-year budded apple trees.

A treatment using one application of otox (20 per cent lindane) spray applied at the rate of 1.56 pounds of lindane per acre to one-year budded apple trees was as effective as a treatment using the same level of lindane but making two applica-tions, one during the first and one during the second growing season. The percent-age infestations at digging time was 13.59 and 11.96 respectively. When one appli-cation of lindane was made during the se-cond growing season, only, the percent-age infested trees was 42.48 and that for the untreated check 56.72 per cent.

Sprays of 2 per cent chlordane, 0.012 per cent endrin, 0.026 per cent gamma isomer of benzene hexachloride, applied in 200 gallons of spray to infested scion trees, did not significantly affect the es-tablishment of buds from these trees when budded to apple seedlings.

Sprays of 0.12 per cent endrin, 0.029 per cent isodrin, 2 per cent chlordane, and 0.026 per cent gamma isomer of ben-zene hexachloride, when applied at the rate of 200 gallons of finished spray per acre to budded seedling apple trees, one day following the budding operation, did not significantly affect the establishment of buds. Although the incidence of aphid infested trees was very low in the experi-mental plot, all treatments were signifi-cantly better than the control. Following an additional application during the first growing season the percentage of infested trees in the treatments was: chlordane 14.70, Gammol 17.38, isodrin 20.40, endrin 41.19 and untreated control 51.86.

Sprays of 0.1 per cent isodrin: 2 per cent chlordane; Gammol (2 pounds gamma isomer in 100 gallons of spray); and Black Leaf "40" 1:200 with soap gave complete control of aphids when applied to heavily infested three-year apple trees following the digging operation. The results were based on examination of the trees when removed from storage the following spring.

## PHYSIOLOGY OF DWARFING IN APPLE[1]

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Dwarf apple trees are commonly produced by propagating standard varieties with short trunk sections of a dwarfing stock. The dwarfing stem section causes less growth, earlier fruiting, and more highly colored fruit than is found in standard trees. The physiological action of the dwarfing interstem was studied.

A length x diameter square factor for measurement of top growth was compared with the seasonal dry weight increase of greenhouse trees. A correlation coefficient, $r = 0.94$, was obtained which showed that the $L \times D^2$ factor could be used as an estimate of dry weight increase. Growth measurements of own-stem, dwarf interstem, bridged dwarf interstem, and Golden Delicious interstem trees showed that dwarf interstem trees produced less top growth and fewer lateral branches than did the other three treatments. Root growth of dwarf trees was reduced significantly below the root growth of own-stem. The root reduction was about equal to the reduction in leaf area of dwarf trees.

Habits of growth of field grown dwarf, bridged, and own-stem trees were compared. The narrow crotch angles and spreading tops of the dwarf and bridged trees were distinctly different from the wide crotch angles and upright tip growth of own-stem trees. An antiauxin mechanism is suggested.

Graft unions of Clark Dwarf with Golden Delicious showed no evidences of incompatibility conditions. Radial checking of dry Clark Dwarf interstems and profuse bark development on the Clark Dwarf interstems indicate that this stock is similar in anatomical structure to the dwarfing stocks used widely in Europe.

A series of studies was run to evaluate translocation activity of the interstem. Nitrogen translocation was studied by determining nitrogen accumulation in leaves following application of fertilizer to a low-nitrogen soil. Own-stem trees accumu-

lated nitrogen somewhat more rapidly tha did the dwarfs. Golden Delicious inter stem trees accumulated nitrogen mo rapidly than dwarf trees after the gra unions were well developed. Bridged ir terstem trees tended to occupy an inter mediate position between dwarf and own stem trees.

Analysis of bark strips following appli cation of radioactive carbon dioxide to leaf of a dwarf tree showed no evidence sugar accumulation at the graft union c in the interstem. The erratic results ot tained with one tree suggest some of th complexities involved in using this methc of studying translocation in the apple Chromatographic analysis showed tl photosynthate involved in translocation t be glucose.

Loss of water from dwarf, bridged, an own-stem trees measured over variou periods showed that water loss per unit c leaf area was approximately equal fo trees on the three stem treatments Transport of water did not appear to b effected by the graft unions or by the in terstems.

Leaves from field grown trees of own stem, dwarf, and bridged stem treatment were used for reducing sugar, reserve polysaccharide, and total nitrogen deter minations. Dwarf trees were highest own-stem trees lowest, and bridged tree: were intermediate in reducing sugar con tent. Reducing sugar content decline from June 27 to August 28 in all treat ments. Reserve polysaccharides and to tal nitrogen content were not significantly different for the three treatments. A lin ear increase occurred from June 27 tc August 28 in both materials.

The dwarf interstem effects observed ir this study were: (1) reduced growth, (2) possible interference with nitrogen trans location, (3) growth habit differences, and (4) high reducing sugar above dwarf inter stems. Effects (2) and (4) suggest that the dwarf interstem interferes with the translocation of organic materials through the trunk. Effect (3) suggests hormone actions. The reduced growth could have been due to either or both of these. Reduced growth, spreading growth habit, and higher sugars in the tops would tend to favor early fruiting, and dwarf trees commonly fruit the third year in the orchard. Once initiated, fruiting itself has a dwarfing effect which would accentuate the continuing action of the interstem.

1 a. Chairman of Committee, H. L. Lantz, Dept. of Horticulture, and W. E. Loomis, Dept. of Botany and Plant Pathology.

   b. Doctoral Thesis No. 1329. Submitted July 19, 1952.

2 a. B.S. University of Vermont, Burlington, Vt., 1948. M.S. Iowa State College, Ames, Iowa, 1949.

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## APPLICATION OF EXPECTATION MODELS TO LIVESTOCK PRODUCTS₁

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The purposes of this study were (1) to
formulate possible expectation models
which could be utilized in forecasting
prices and yields and (2) to test the ef-
ficiency of these models in terms of the
magnitude of the errors which would re-
sult from their use.

Twelve different expectation models
were tested for efficiency in predicting
future values of price or yield series.
The average model projected a constant
value, namely the average of the series
as the predicted value. In a variant of
the average, the cumulative model, the pre-
dicted value was a moving average
whose length increased with an increase
in the length of the séries. In the ran-
dom and current year models, the pre-
dicted value was based on a single obser-
vation; in the random model, the predic-
ed value was chosen at random from the
last values of the series; in the current
year model, the predicted value was last
year's value of the variable. The five
year moving average and the five year
weighted moving average models intro-
duced some stability into the predicted
values by using the indicated averages;
in addition, the weighted moving average
model emphasized the importance of the
current period. The trend and reverse
trend models utilized the concept of
trend which is based on the difference
between consecutive observations. The
trend from average and the reverse trend
from average models utilized both aver-
age values and trends in the formulation
of the predicted value. Each of these
models utilized some characteristics of
particular series, namely, the average
of several observations, the short-term
linear trend, or the relationship between
consecutive observations in making pre-
dictions. The random model was unique
because, in addition, it utilized various
random influences in the invironment as
a basis of prediction. Two other models,
namely, the outlook and the parallel
price models, did not utilize any charac-
teristics of the series whose values were
being forecast; the outlook model used

the forecasts of government agencies and
the parallel model utilized the prices of
similar periods in the past as the basis
of price prediction.

All the expectation models were tested
for efficiency on empirical series, and
all but the cumulative, outlook and par-
allel models were tested on hypothetical
series. The hypothetical series were
three in number; the first, a generalized
autocorrelated series; the second, a se-
ries with autocorrelation of positive uni-
ty, and the third, a random series. The
empirical price series consisted of
steer, hog, lamb, egg, and butterfat
prices, each extending over the period
from 1917 to 1950, inclusive. The em-
pirical yield series consisted of eggs laid
per hen, milk produced per cow, and pigs
weaned per litter on twenty different
farms; each series on each farm extend-
ed for a period of twenty consecutive
years or more.

The generalized autocorrelated series
was useful in developing a set of formu-
las which would be applicable to any auto-
correlated series; the random series and
the series with autocorrelations of posi-
tive unity are two particular cases of
this generalized series. The application
of the expectation models to a random
series resulted in several conclusions;
the most important of these was the use-
fulness of the moving average model in
forecasting. The series with autocorre-
lations of positive unity was less fruitful
in its results; it was possible, however,
to indicate the efficiency of the current
year model.

The application of the models to the
empirical data indicated the magnitude of
the errors which results from a series
with parameters intermediate in value
between that of a random series and that
of a series with autocorrelations of posi-
tive unity. In addition, it was possible
to obtain the percentage of extreme er-
rors and the range of the errors. This
allowed a more complete evaluation of
the efficiency of the various models as
indexes of uncertainty. The most effi-
cient models in prices were the outlook,
current year, parallel and the five year
weighted moving average models. In
yields, the current year model was the
most efficient for the egg and milk se-
ries, while the average and moving av-
erage models were most efficient in the

pig series. The efficiency of the current year model in prices, and in the egg and milk series in yields was partly offset by the existence of extreme errors.

On the basis of the theoretical and empirical evaluation of the models, two policy recommendations appear possible. First, given a series with an imperfect degree of positive autocorrelation, farmers could be advised to use the current year model; it is one of the highest in efficiency and also one of the simplest to adopt. In price series the efficiency of the current year model may be further increased by supplementing it with outlook information. Since the outlook forecasts were particularly accurate in forecasting large price changes, farmers could be advised to formulate expectations on the basis of the current year model, but to shift to the outlook model whenever severe price changes were indicated. Utilizing the outlook informa-

tion would be particularly useful in reducing the number of extreme errors in the current year model. Second, for yield series which tend to approximate randomness, the five year moving average model may be recommended for use by farmers. Its efficiency is only one-fifth less than that of the average model, and it is more practical for farmers to adopt than the average model, as the average value of a series is not usually known. Five years is selected as the length of the moving average, as an interval of this length is a convenient memory period for the farmer. The use of a longer moving average would allow a small increase in the efficiency of the model; its use is not recommended as the increased efficiency may be more than offset by the memory error introduced as the farmer attempted to recall the more distant yields or prices.

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## APPROXIMATION OF SERVOMECHANISM TRANSIENT RESPONSE[1]

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Although servomechanism design requirements usually specify the output time response to some standard form of time input signal, the design process is commonly performed on a frequency response basis. The existing wealth of knowledge and experience in steady-state alternating current circuit theory and in feedback amplifier performance justify this design procedure. Under these conditions the need to transform from the frequency to the time domain and vice versa is very great.

Exact mathematical methods of performing these transformations for linear systems under very general conditions exist but unfortunately do not lead to closed form results except in very special cases.

The purpose of this study was to ingestigate a certain approximation of the inverse

*The actual behavior in this range is difficult to determine by the method used.

1 a. Chairman of Committee, W. B. Boast, Dept. of Electrical Engineering.
  b. Doctoral Thesis No. 1306. Submitted July 9, 1952.
2 a. E.E. Cornell University, Ithaca, New York, 1938. M.S. University of Rochester, Rochester, New York, 1941.
  b. Graduate Fellow, Dept. of Electrical Engineering.

Laplace transform from the frequency to the time domain based on the behavior of the imaginary component of the closed-loop system transfer function. This imaginary component was assumed to be zero for all angular frequencies above an empirically determined cutoff point, $\omega_o$. Further assumptions were made that the imaginary component decreased linearly in the range where its absolute value was less then one tenth*, that eighteen point graphical integration would give sufficiently accurate Fourier coefficients in an expansion of the imaginary component as a sine series, and that the contributions to the time response of terms higher than the fourth would be negligible.

The cutoff frequency, $\omega_o$, was selected on the basis of the results obtained for four systems having varied open-loop transfer functions. These systems were restricted by the necessity of analytically performing the exact transformation as a basis of comparison. Excellent results were obtained in the systems investigated when $\omega_o$ was taken equal to 1.3 times the frequency at which the imaginary component was equal to minus .1 and decreasing. The figure of 1.3 represents a lower limit set so that the part of the imaginary component excluded from consideration did not introduce more than five per cent error

into the results. The upper limit for five per cent error is dependent on the validity of the latter three assumptions and varies widely in the systems studied.

The method results in the following expression for the system response, h(t) to a unit impulse input.

$$h(t) = 2\omega_o \sin \omega_o t \sum_{n=1}^{4} n(-1)^n \frac{a_n}{n^2\pi^2 - \omega_o^2 t^2} \quad (1)$$

where

$$a_n = \frac{2}{\pi} \int_o^{\omega_o'} I(\omega) \sin \frac{\pi}{\omega_o} \omega \, d\omega \quad (2)$$

$I(\omega)$ being the imaginary component of the closed-loop transfer function. $h(t)$ is easily calculated from this expression since the term $\sin \omega_o t$ occurs outside the summation sign.

Procedures are included for deriving the imaginary component of the closed-loop transfer function as a function of frequency when the open-loop transfer is available either analytically or as a plot in polar (Nyquist) or log modulus vs angle coordinates.

The proposed method was found to be valid for times less than $\frac{4\pi}{\omega_o}$ when four terms of the series were retained, and the labor of computation was materially less than that required by other methods giving results of comparative accuracy. However, this method should be checked on more complicated systems using an analog computer, or equivalent means, to determine the correct results for comparison.

## MANAGEMENT ASPECTS OF AND EDUCATIONAL CRITERIA FOR SCHOOL LUNCH PROGRAMS IN IOWA[1]

### BEATRICE ELIZABETH DONALDSON[2]
Departments of Institution Management and Vocational Education

### Part I. Management Aspects of School Lunch Programs in Iowa.

The purpose of this part of the study was to investigate problems in the management and operation of lunch programs in Iowa schools. This research was a part of the Iowa State College Agricultural Experiment Station Research Project 1021, the Nutritional Status of Iowa School Children: the School Lunch as a Contributing Factor.

During the school year of 1948-49 data were collected in 25 schools drawn at random and representing junior and senior high, elementary and schools with 12 grades in one unit. Of the pupils enrolled in these schools, 36 per cent ate the school lunch.

Analyses of covariance indicated that, other than variation attributed to the num-

ber of lunches served, there were real differences among the three groups of schools in the labor time scheduled for personnel, the kitchen area, and the labor, other and total cost of operating the lunch programs; there was no real differences in the food costs. Other than variation due to seating capacity, there were differences in the dining table area but not in the dining room area. There was wide variation among schools within each group in the food cost and the dining area.

The average rates of production were 7.9 lunches per man-hour of labor, 7.5 minutes of labor time per lunch served and 7.2 lunches served per minute per serving line. An average of one third of the labor time was used for food preparation, one third for cleaning and one fifth for serving. The greatest percentage of time was used for cleaning in the high and elementary schools and for preparation in the schools with 12 grades. The average kitchen area was 2.3 square feet per lunch served; in 21 schools the space exceeded the minimum standard. In 16 schools the dining space was inadequate. The average length of the basic food route was 57.6 feet. Most of the schools in larger cities had more institution equipment than those in smaller towns. None of the kitchens in the latter schools was adequately equipped.

The rates of production and the division

of labor time seemed to have been affected by the number of lunches served, space and layout of facilities, amount, type and condition of equipment, organization of work, training and experience of personnel, cleaning duties required and the number and type of food items prepared and served.

Food prices, wage levels, monetary value of donated commodities and the amount of other expenses paid from lunch funds influenced the expenditure distribution of income; an average of 56.8 per cent was used for food and 31.8 per cent for labor. The average total cash received per revenue lunch served during the school year of 1948-49 was 27.3 cents and the range was from 24.8 for the schools with 12 grades to 32.5 cents for the high schools. The average per meal total cost was 26.5 cents for the total group and 31.6 for the high schools. The average per meal food costs were 17.1, 12.8 and 15.1 cents for the high, elementary and schools with 12 grades, respectively, and averaged 15.1; the labor costs were 9.5, 8.3 and 7.8 cents and averaged 8.4.

The total weight of the food returned averaged 5.9 pounds per 100 students served. Of the food served, 5.08 per cent was returned, in the high schools 2.41, elementary 6.34, and schools with 12 grades 5.49 per cent. Salads, vegetables, desserts, main dish items, breads and sandwiches, milk, fruits and fruit juices were returned in order of decreasing amounts.

An average of one third of the recommended nutritional allowances for a child ten to 12 years old was supplied by the lunches prepared in 24 schools except for calories and iron. When the adequacy of the lunches in the high schools was determined on the basis of the dietary allowances for boys from 13 to 15 years, only protein, thiamine, riboflavin and ascorbic acid were adequate. The menu items in the more nutritionally adequate lunches were relatively more expensive and usually required more preparation time than those in the lunches which were less adequate.

On the basis of the findings it was recommended that: training for school lunch personnel emphasize menu planning in relation to organization of work, cost and nutritional adequacy; school personnel request assistance in planning and equipping lunchrooms; that more comprehensive studies be made regarding the factors influencing participation, labor time and cost and the acceptability of food, adequacy of dining room space and facil-

ities, school lunch expenditures and mo etary and nutritive value of donated con modities.

### Part II. Educational Criteria for Scho Lunch Programs.

The purpose of this part of the stud was to develop a set of criteria which ca be used to determine to what extent school lunch program is an integral pa of the total school program. After devel oping a concept of the basic characteris tics of such a program, the followir criteria were proposed: there are soun policies for the administration of th school lunch program; the school admin istrator assumes responsibility for th administration of the program; teacher assume and share responsibilities fo promoting the educational effectivenes of the program; pupils participate in ed ucational activities related to the pro gram; the professionally trained manage and the school lunch personel contribut to the educational effectiveness of th program; community members partici pate in the program.

Using educational practices which ha been classified according to the six pro posed criteria, a schedule was develope for obtaining data believed to be neces sary for determining to what extent the proposed criteria are fulfilled in a give school. The schedule was tested in ter schools to determine whether the questions would elicit the information believed to be necessary, whether the schedule was applicable to various types of schools and whether the proposed criteria provided a practical basis for this kind of evaluation.

After revisions were made in some questions and the form for recording the data, the schedule was applicable to the ten schools regardless of size of enrollment, number of pupils served, kind of management of the lunch program and type of school.

The schedule was recommended for use by federal or state agencies, state supervisors, school personnel or members of a community to determine the extent to which a school or group of schools is fulfilling the criteria, to secure some knowledge of the attitudes of schools and communities regarding the educational potentialities of lunch programs, to determine needs for assistance in planning methods whereby the criteria can be more completely fulfilled and to suggest possibilities which exist for making the lunch program more educational.

# CONDUCTANCES, TRANSFERENCE NUMBERS, AND ACTIVITY COEFFICIENTS OF SOME RARE EARTH CHLORIDES IN AQUEOUS SOLUTION[1]

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Department of Chemistry

The conductances, transference numbers, and activity coefficients of aqueous and, and activity coefficients of aqueous at the equivalence pH were measured at concentrations up to 0.1 normal. The measurements were made on the chlorides of neodymium, dysprosium, holmium, erbium, thulium, and ytterbium. In addition to these measurements, a new mathematical treatment of the electrophoretic part of the Onsager Theory of conductance is carried out. This resulted in better agreement between the theoretical and experimental values of the transference numbers and conductances.

The rare earth chloride solutions were brought to the equivalence pH value before measurement of the properties was undertaken. This equivalence pH value was determined by titration of an aliquot of the stock solution with acid. The titration was followed with a pH meter. It was found that the clear "solutions", at pH values of 6 to 6.5, which had been previously made by dissolving anhydrous rare earth chlorides in water in a closed system, actually contained small amounts of colloidal oxide or basic salt. This was negligible for the light members of the rare earth series, but exceeded by a small amount the normal experimental errors for the heavier members of the series. The small effect of this deviation was demonstrated by repeating the measurements which had been made previously on neodymium chloride, erbium chloride, and ytterbium chloride.

The conductances were measured, using a Jones bridge and its accessories, for solutions ranging from 0.0003 normal to 0.1 normal in concentration. Since these measurements were made at the equivalence pH values, which were below the neutral point, a correction for conduction of current by the hydrogen ion was necessary for low concentrations. The equivalent conductances obeyed the simple Onsager Equation up to about 0.008 normal and agreed with the new mathematical treatment of Onsager's Theory up to about

1  a. Chairman of Committee, Frank H.
      Spedding, Dept. of Chemistry.
   b. Doctoral Thesis No. 1400. Submitted
      June 1, 1953.
2  a. B.A. Gustavus Adolphus College,
      St. Peter, Minnesota, 1949.
   b. Graduate Assistant, Institute of
      Atomic Research.

0.008 normal.

The transference numbers were determined by the moving boundary method for solutions from 0.01 normal to 0.1 normal in concentration. The simple Onsager Equation predicted much lower transference numbers than were measured. When the mathematical extension of the theory of Onsager was developed, however, the theory agreed with the experimental values much more closely.

The conductances and transference numbers both exhibit similar changes with atomic number. The experimental values of both the transference numbers and the equivalent conductances at any concentration remain nearly unchanged for the first five or six rare earth chlorides. A relatively large change in these properties then takes place between samarium chloride and holmium chloride, and again the values remain nearly unchanged for holmium, erbium, thulium and ytterbium chlorides. This probably is due to changes in the hydration number of the rare earth ion, but has not been fully explained as yet. It would be of interest to study further the structure of the hydrated chlorides in this connection.

The activity coefficients were determined by a measurement of the E.M.F. of cells with transference in the concentration range, 0.002 normal to 0.1 normal. The experimentally obtained activity coefficients were found to agree with the predictions of the Debye-Hückel Theory throughout this range with a precision of about $\pm 0.2$ per cent. The values of $\overset{\circ}{a}$, the distance of closest approach of the ions, indicate that the rare earth ion has one layer of water molecules which adheres rather firmly to the central ion. The $\overset{\circ}{a}$ values obtained from the experiments do not increase or decrease in a regular fashion throughout the series, but are larger for the high atomic number rare earth chlorides than for the lower members of the series.

A new mathematical treatment of the electrophoretic part of Onsager's Theory of conductance is described, which employs graphical methods to evaluate integrals which were only approximately evaluated by Onsager. The approximate methods, while satisfactory for 1-1 electrolytes, are unable to explain the transference number behavior of unsymmetrical

electrolytes. The extension of the mathe-
matics resulted in much better agreement
of experiment with theory for the trans-
ference numbers of unsymmetrical elec-
trolytes. This treatment of the theory was
applied to the conductances and transfer-
ence numbers of neodymium chloride, er-
bium chloride, and calcium chloride. The
calculated conductances agreed with the
experimental values up to about 0.008 nor-
mal, compared with agreement to about
0.0008 normal in the case of the simple
theory. The calculated transference num-
bers agreed well enough with the experi-
mental values to explain the large discre-
pancy which had existed between theory

and experiment for the transference num
bers of unsymmetrical electrolytes. I
addition, the possibility of determinin
the mean distance of closest approach o
the ions, $\overset{\circ}{a}$, from conductance measure
ments was recognized. This would mak
it possible to calculate activity coefficient
from conductance measurements, usin
the equation of Debye and Hückel, whic
includes the parameter $\overset{\circ}{a}$. These calcu
lated activity coefficients should certainl
be better than those obtained from th
simple limiting law, since the theoretica
basis for the inclusion of $\overset{\circ}{a}$ in the theorie
of both activity coefficients and conduc
tances demands a single value for $\overset{\circ}{a}$.

## APPROXIMATE SOLUTION OF BOUNDARY VALUE PROBLEMS[1]
### I BY MINIMIZATION OF THE LEAST SQUARE ERROR
### II BY USE OF FINITE DIFFERENCES

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Department of Mathematics

The first part of this study deals with
the method of least square error in ob-
taining an approximate solution of a
boundary value problem involving La-
place's differential equation in two di-
mensions. The terms of the proposed
solution $\Phi_n(x,y) = \sum c_i f_i(x,y)$ where $i = 1,$
$2, \ldots, n,$ are chosen as solutions of the
governing equation $L(\Phi) = 0$. In particu-
lar they are selected from exact solutions
of related boundary value problems whose
boundary values partly agree with those
of the required problem. The constants
in $\Phi_n(x,y)$ are determined by minimizing
the integral of the square of the error
along the entire boundary. The usual
necessary conditions for a minimum of
this error integral $I(c_i)$ lead to a non-
homogeneous finite linear system for the
unknowns $c_i$.

After it is shown that the method is cap-
able of producing the exact solution in
certain examples, it is applied to an ex-
ample with mixed boundary conditions at
the edges of a square region. In another
example a rectilinear region involving a
reentrant corner has edge conditions as-
signed along its six bounding lines. There

is no known analytical solution for these
problems. The least square method
yields results which are in good agree-
ment with the numerical results obtained
by an iteration procedure employing fin-
ite differences methods. Although an ef-
fort was made to determine whether a
selection of functions from exact solu-
tions of related boundary problems would
yield more favorable results than those
produced by a general choice of functions
satisfying $L(\Phi) = 0$, no conclusions were
made. It is believed that the type of mix-
ed boundary conditions in the problems to
which the least square method was appli-
ed is responsible for this. The main
task involved in using this method lies in
the choice of terms to be set into the ap-
proximate expression. There seems to
be no rule that can be followed to help in
choosing these terms. In general it is
suggested that they might be chosen from
among any standard functions which sat-
isfy the given differential equation, which
also conform to the symmetry of the pro-
blem and which are a part of known an-
alytical solutions of similar problems.

In the second part, a finite difference
method of solving Poisson's differential
equation in two dimensions is developed.
The method recognizes the importance of
Green's theorem for the solution of bound-
ary value problems. Let the field over
which the function $\Phi(x,y)$ is to be deter-
mined by covered by a network of squares
of side h. When the finite difference
statement equivalent to the integral state-

1 a. Chairman of Committee, D. L. Holl,
     Department of Mathematics.
  b. Doctoral Thesis No. 1349. Submitted
     December 12, 1952.
2 a. B.S. Iowa State College, Ames, Iowa,
     1935.
     M.A. University of Southern California
     Los Angeles, Calif., 1943.
  b. Instructor, Dept. of Mathematics.

⁻ it of the theorem is formed, the ap-
⁻iximate value of the required function
ⁿ iny point of the network may be com-
ⁿed in terms of the known values at the
ⁿwork points on the boundary. The
ⁿtement for Green's theorem involves
⁻auxiliary function $\Psi(x,y)$. The method
⁻uires that $\Psi(x,y)$ be harmonic at inter-
⁻ points of the network and that $\Psi_x$ and
be zero along the right hand and upper
ⁿndaries, respectively. The main task
olved here is the formation of $\Psi$-gridᵣ.
ⁿ method for forming the appropriate
ⁿmonic $\Psi$-grids is outlined in this
dy. When they are applied to the dif-
ⁿence statement for Green's theorem,
y give rise to a non-homogeneous fin-
l linear system of not more than $2n-2$
ⁿations in the $2n-2$ unknown $\Phi$-values.
ese $\Phi$-values lie on the first inner con-
ir of points just inside the $2n$ points of
ⁿ upper boundary. ' The remaining $\Phi$-
lues may be computed by using the har-
ⁿnic relationship, i.e. any interior
ⁿint is the mean of its four neighboring
ⁿints. Or if other approximate $\Psi$-grids
e formed as indicated in the paper, they
ⁿve rise to equatiᴏns which express each

of the remaining $\Phi$-values in terms of the
boundary values and the $\Phi$-values already
determined.

The method is applied to the solution of
a boundary value problem involving a
square cross-section where the boundary
values are zero along the lower side,
functions of x and y along the upper and
lateral sides, respectively. In another
example the torsion problem for an angle
section is solved. This method yields
results which are in excellent agreement
with the numerical results obtained from
the same iteration procedure employed
before.

The method is less time consuming than
most other procedures of finite differ-
ences and may be carried out by means of
the ordinary desk calculation. The expo-
sition shows how this method may be ex-
tended to modified square fields, rect-
angular fields and to cylindrical regions
where the axis is an axis of symmetry.
The method may be extended to biharmon-
ic difference equations. The procedure
for such a solution including the method
of forming the appropriate $\Psi$-grids is out-
lined in the paper.

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# FORM FUNCTIONS OF NON-LOCALIZABLE INTERACTIONS[1]

## MARVIN EMERSON EBEL[2]
### Department of Physics

Certain well-known difficulties are en-
ountered in current theories describing
ementary particles by quantized wave
elds. Notably, divergent integrals re-
ilt from computations of physically-
observable quantities which are known to
e finite. As a consequence, a number of
echniques have been suggested recently
or removing these infinities.

An analysis is made of one such propo-
al, that of a non-local interaction be-
ween the fields. It is assumed that the
nteraction energy density is a function of
ield operators at three points, instead of
ust one, a form function being used to
weight more heavily contributions from
earby points. The additional freedom

provided by the introduction of the some-
what-arbitrary form function is sufficient
to permit making previously-divergent in-
tegrals converge.

It is shown that, for the most general
form function, an energy-momentum ten-
sor and a charge-current four-vector in
the usual sense will not satisfy a differen-
tial continuity equation; energy, momen-
tum, charge, and current are conserved
only over the collision as a whole. As a
result, a Hamiltonian in the familiar form
does not exist, and it is necessary to find
the S-matrix for the process directly from
the equations of motion. A method of do-
ing this is presented. Rules analogous to
those of Feynman and Dyson are devel-
oped, so that the matrix element for a
given process may be written down directly.

The theory is made relativistically-
covariant, invariant under charge conju-
gation, and invariant under changes in
gauge of an external electromagnetic field,
by placing various restrictions upon the
form function. These restrictions limit
the form function to be a function of only

three variables. It is shown that the non-local interaction gives results similar to those which would be obtained from a theory providing for the propagation of virtual particles from one point of the interaction to the other, with the form function merely giving the distribution in masses of these virtual particles.

The transverse self-energy of the electron and the lifetime of a neutral spin zero meson against two-photon decay are computed, using a Gaussian form function. If the interaction between electron and electromagnetic field is assumed to occur over a region whose diameter is of the order of magnitude of an electron Compton wavelength, then the electromagnetic mass is only about 10-3 the ordinary mass of the electron.

Taking the range of the meson-nucleon interaction to be no greater than the nucleon Compton wavelength, a meson lifetime of about $2 \times 10^{-18}/g^2$ sec. is obtained with scalar coupling between the fields, and a lifetime of about $2 \times 10^{-14}/g^2$ sec. for pseudoscalar coupling. In these g is the unknown meson-nucleon coupling constant, which may be presumed to be about 0.5. The lifetime under scalar coupling is about $10^3$ smaller than that

obtained by the use of regulators, but tl pseudoscalar result is approximately tl same as that given by the previous calcu lations.

The appendices define and explain tl various Green's functions used, the cor cept of charge conjugation, the method evaluation of matrix elements, and tl Gupta-Bleuler method of quantization the radiation field. The actual calcula tions involved in computing the mesc decay probability are also included.

The general outline of the theory, th reduction in the number of variables the form function, and the technique assuring invariance under gauge trans formations of the external electromagne tic field have been given by other workers although the treatment here is slightl different in some respects. The use the requirement of invariance under charg conjugation to limit the form function, an the application of the theory to quantur electrodynamics are new, although th techniques used are the same as thos which have been applied to fields in loca interaction. The formulation of rules fo writing the S-matrix elements directly and also the interpretation given to th interactions are original with this work.

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# DECARBOXYLASE ACTIVITY OF PSEUDOMONAS SPECIES FOUND IN DAIRY PRODUCTS[1]

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Many of the species of Pseudomonas which may be found in dairy products are decidedly protiolytic and some are able to produce a markedly alkaline reaction in such substrata as sterile milk. Little information is available about the enzyme systems active in protein degradation by these organisms. The studies reported here were undertaken to determine the extent of amino acid decarboxylase activity among certain Pseudomonas species and to establish the conditions under which these enzymes are produced and are active against their specific substrata.

The ten species tested for decarboxylase

activity were P. fragi, P. fluorescens P. putrefaciens, P. aeruginosa, P. gra veolens, P. mucidolens, P. cyanogenes P. synxantha, P. ichthyosmia and P. vis cosa. The medium usually used for cul turing the organisms consisted of 1 pe cent casamino acids, 1 per cent glucose and 0.068 per cent potassium phosphate (monobasic). Fifty ml. portions of this medium were dispersed into 32 oz. bot tles, sterilized at 250° F. for 15 minutes cooled to room temperatures, inoculatec with a cell suspension and incubated for 24 hours. The pH of the medium at the time of inoculation ranged from 5.36 to 5.65. The incubation temperature was 18° C. for all species, except that P. aeruginosa was incubated at 37° C.

The cells were harvested by centrifug ing the 24 hour culture medium at 420( rpm. for 15-18 minutes. The supernatant fluid was decanted off and the remaining cells washed twice by resuspending in physiological saline. The final suspen-

ion was made by diluting the cells with enough saline to give a cell population of 000,000,000 per ml., as determined by optical density.

The decarboxylase activity was measured by the amount of carbon dioxide given ff when the cell suspensions were allowed to react with an amino acid substrate in the Warburg constant-volume respirometer. The amino acids used for testing were arginine, glutamic acid, histidine, lysine, ornithine and tyrosine. The flask contents during the manometric measurements were 2.0 ml. of phosphate buffer pH 6.0), 0.5 ml. of cell suspension and .5 ml. amino acid substrate previously adjusted to various pH levels. All measurements for decarboxylase activity were made at $30{+}0.2°$ C., using atmospheric air as the gas phase. Manometric readings were made at 5 minute intervals for at least 1 hour and the data reported as microliters of carbon dioxide liberated per hour.

When the decarboxylase activity was measured on cells grown in various media, no activity occurred unless the specific amino acid was present in the growth medium. Based on this fact, it is believed that the decarboxylases are adaptive enzymes produced only when the specific substratum is present in the free form. However, many species lack the potential to produce certain of the decarboxylases, even under the most favorable conditions. Of the buffers studied, the Clark and Lubs phosphate buffer appeared to be most satisfactory, whether in the growth medium or in the Warburg reaction flasks. This buffer apparently did not exert as strong a buffering effect, thus allowing the pH to drop to lower levels during growth of the cultures, a condition which is more conducive to higher decarboxylase activity.

Under the conditions of the manometric determinations, the largest decarboxylase activity occurred within the pH range of 3.25 and 4.25 for the six amino acids studied. As the reaction levels approached the extremes of pH 2.5 and 5.6, the amount of enzyme activity decreased. In no case were there measurable amounts of carbon dioxide liberated when the reaction level exceeded pH 6.0.

An incubation temperature of 18° C. was found to give the highest decarboxylase activity for all species studied, except that $\underline{P}.$ aeruginosa gave the best response when cultured at 37° C. These optimum temperatures were found by com-

paring results from 15, 18, 21 and 24° C. and 25, 30, 37 and 45° C., respectively. Using the optimum growth temperatures for decarboxylase activity, time trials showed that 24-hour incubation yielded cultures of greater enzyme activity then did 18, 30, 36 or 42 hours. Based on the cell population for the different time periods studied, the maximum growth was obtained between 24 and 30 hours of incubation. Since the time for active cell growth and maximum decarboxylase activity are about equal, it appears that greatest enzyme activity is attained late in the logarithmic growth phase. Apparently the decarboxylases are not produced in appreciable quantities in the early growth cycle and there is considerable loss in activity after reaching the stationary growth phase.

The distribution of the decarboxylases with these ten species of Pseudomonas is extremely variable. P. fluorescens, P. putrefaciens, P. cyanogenes, and P. synxantha each produced only one decarboxylase; P. ichthyosmia produced two decarboxylases; P. graveolens produced three decarboxylases; P. fragi and P. mucidolens each produced four decarboxylases and P. aeruginosa and P. viscosa each produced five of the six decarboxylases for which tests were made. The level of enzyme activity against any one amino acid was quite variable among the different cultures. When a culture attacked more than one amino acid, the level of activity was not the same against each of the different compounds.

Several reports have suggested that pyridoxine is required as the coenzyme for the decarboxylase enzymes. In some cases, the addition of pyridoxine to the casamino acids - glucose - phosphate medium brought about a very small increase in production of some decarboxylases. In all cases where enhancement occurred, the increase in enzyme activity was less than one-fold.

The number of cultures employed is not such as to permit conclusions as to whether qualitative differences in possession of amino acid decarboxylases might be of value in the taxonomy of the genus Pseudomonas. However, conditions necessary for maximum decarboxylase production and activity for specific substrata are shown for the ten Pseudomonas species found in dairy products. These decarboxylases would be active in dairy products only when acid-producing organisms had dropped the pH to levels somewhat below that normally encountered in fresh milk.

## YIELD AND PRICE EXPECTATIONS FOR PRIMARY AGRICULTURAL PRODUCTIO[1]

ABDEL HAMID FAWZY EL-ATTAR[2]
Department fo Economics and Sociology

Since farm production takes time, in certain cases up to several years, the role of expectations in economic planning is highly important. The objective of this study was to test the predictional accuracy of various price and yield expectation models which can be used by farmers at the present time.

Fourteen mechanical price and yield expectation models were tested for efficiency in prediction. Models were selected which were based on specific and general experience of the farmer. These models are: (1) random price and yield, (2) current price and yield, (3) five-year moving average price and yield, (4) ten-year moving average price and yield, (5) weighted moving average price, (6) average price and yield, (7) trend price, (8) trend from average yield, (9) reverse trend price, (10) reverse trend from average yield, (11) outlook price, (12) parallel price, (13) future market price, and (14) preseasonal rainfall.

For evaluating the efficiency of each price or yield model in prediction, three measures of errors are used. Those measures are the average error as a percentage of the mean, the frequency distribution and the coefficient of the total range. They were selected because of their meaningfulness to farmers in formulating production plans and because of the amount of information they provide about error or uncertainty.

Most models had a smaller magnitude of errors when used to predict the prices of tobacco and hay than when used to predict the prices of other crops. The smaller error in predicting tobacco prices is partly caused by its price series covering a period (1933-1951) when support prices prevailed and had a stabilizing effect. The smaller error for hay is due in part to the fact that its series has the smallest coefficient of variation. The various models are inconsistent in the magnitude of their errors for the rest of the crops (i.e., larger errors for one model and smaller for another). The

ranking of the price series on the basi of a model's mean error is somewhat i agreement with its ranking on the basi of the extreme error and the range ( errors. However, that ranking on th basis of the three measures of error : not always in agreement because a mode which has approximately the same mea errors in predicting different price se ries may vary in the shape of the fre quency distribution of its errors.

A comparison of the errors which woul be obtained if the eleven price model were mechanically and consistently use by farmers] was made. For all price considered as a group, each model i evaluated on the basis of its average ef ficiency where the average rank of eac model is an indicator of its average effi ciency. The comparison of the pric models on the basis of their ranking ac cording to three measures of error: showed that the weighted moving aver age, outlook, future market, current an parallel models composed the first grou] (best) in predictional efficiency for al prices considered as a group. The five year moving average, reverse trend, ten-year moving average, average an random models formed the second grou] which was less efficient in prediction than the first group. However, within each group the order of the models is altered. The model which has relatively lower (or greater) mean error usually has lower (or greater) range and extreme errors.

The weighted moving average price model has the least mean error, range of errors and percentage of the extreme errors for all prices considered as a group. The outlook price model ranks second least in magnitude of the mean error and fourth least in magnitude of the extreme error and the range of errors. The important feature of this model is the greater ability of the persons who prepare the outlook to accurately forecast major rather than minor economic changes. The future market price model which was only applied to corn and wheat ranked third least in magnitude of the mean error and second least in magnitude of extreme and range of the errors. Since there are no future prices in most years in the months before planting for grain delivery after the new harvest, this model in contrast to the other ten price models would not help farmers in their

duction plans. However, the future market model is useful in other respects. The current and parallel models have larger errors than the previous models. When predicting yields, smaller errors in all models occur with potatoes, oats, corn, and cotton, because the coefficients of variation for the yield series of these crops are smaller than for other crops. Hir, wheat, hay, and tobacco caused larger errors because their coefficients of variation are larger. The ranking of the yield series on the basis of the three measures of error introduced in prediction is more consistent than in the case of prices because of the larger difference in variability between the yield series.

A comparison of the eight yield models is also made. For various yield series, each model is more inconsistent in its ranking than the corresponding price models because yield series do not move the same direction as prices. The yield series are for various crops from different experiment station farms located in various states. The weather conditions and the other factors which affect agricultural production vary according to location and kind of crop. On the other hand, agricultural prices are affected by the same secular forces.

For each crop yield series, the ranking of a model according to the range of the errors is not always in agreement with its ranking on the basis of the mean error or expressed as a percentage of the mean and the percentage of the extreme error. For all crop yield series consid-

ered as a group, the ranking of a model on the basis of the mean error is in approximate agreement with its ranking on the basis of the range of the errors while it differs somewhat but not much with its ranking on the basis of the extreme error. However, the ranking of the models on the basis of the three measures of error led to the conclusion that the average, preseasonal rainfall, five-year moving average, reverse trend, and ten-year moving average models form the most efficient group. The current, random, and trend models have less predictional accuracy for all crops considered as a group. However, within each group of models the order is somewhat altered. The average model gives approximately the same efficiency in prediction as the preseasonal rainfall model while it does not require the complicated calculations of the latter.

On the assumption that the yield and price populations will continue to repeat themselves in the future, farmers may adopt the models to which the least uncertainty is attached in planning their crop production. It is suggested that further research should be conducted in forecasting prices or yields using advanced statistical techniques. It remains to be seen whether the differences in the predictional accuracy between the simple mechanical expectation models (used in this study) and the econometric analysis approach justifies using the latter method with its higher costs.

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# THE FERROMAGNETIC PROPERTIES OF THE RARE EARTH METALS[1]

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The magnetic properties of gadolinium, dysprosium, and erbium metals have been studied in their ferromagnetic ranges.

The absolute saturation magnetization of gadolinium was found to have a linear $T^{3/2}$ temperature dependence between 20-250° K. The saturation magnetization at absolute zero, determined by extrapo-

lation was found to be $253.6 + 0.9$ cgs units confirming the previous work of Trombe. This absolute saturation moment corresponds to about 7/12 Bohr magnetons per atom. The data fell considerably below the theoretical curve predicted by the Debye-Weiss theory of ferromagnetism for the $^8S_{7/2}$ state. The Curie point determined from spontaneous magnetization data was found to be $17.7 \pm 0.3°$ C. This temperature is some two degrees higher than the Curie point determined by a ballistic method using a small applied field of about 23 oersteds, and observing the temperature at which ferromagnetism disappears.

The magnetic moment of dysprosium was measured in applied fields of 4000-18000 oersteds, over the temperature range of 20.4° K to 205° K. The susceptibility of dysprosium was shown to be field dependent below about 175° K. Below 90° K, dysprosium appeared to have true ferromagnetic properties, confirming the previous work of Trombe. An absolute saturation magnetic moment of at least 8 Bohr magnetons per atom was indicated by the data obtained in the temperature range of 31.25° K to 80° K. The magnitude of the measured values of the magnetic moment of dysprosium indicated that the orbital angular momentum of the 4f electrons contribute to the ferromagnetism.

The magnetic moment of erbium wa measured for applied fields of 4000-1800 oersteds over the temperature range o 20.4° K to 71° K. The susceptibility o erbium was shown to be field dependent a about 55° K. The metal exhibits true fer romagnetic properties at 20.4° K. A sat uration moment at 20.4° K of at least 28 cgs units, corresponding to 8.6 Bohr mag netons per atom is indicated by the data The magnitude of the measured values o the magnetic moment of erbium show that the orbital angular momentum of th 4f electron contributes to the ferromag netism.

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# THEORY OF ADSORPTION FROM SOLUTION AND MIXED GASES[1]

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Department of Chemistry

A quasithermodynamic theory of adsorption from solution and mixed gases is presented. The theory is developed from a consideration of conditions for equilibrium between matter in a fixed volume of space in the neighborhood of the adsorbent surface and matter in bulk solution (or gas phase). Where thermodynamic standard states are chosen as pure liquid component at the points of interest (either in a specified neighborhood of the adsorbent surface or in bulk phase) two assumptions are critical in the theoretical development. They are first, that the difference in standard state chemical potentials between component in bulk and component at a point near the surface is given by the Polanyi adsorption potential of the component at the point near the surface as inferred from the pure component gas adsorption isotherm, and second, that the activity of a component is the same function of concentration at a point near the surface as it is in bulk. Possible limitations of these assumptions are discussed.

The theory developed permits the prediction of isotherms for adsorption from solutions and gas mixtures, given isotherms for adsorption of pure components

from the gas phase. Isotherms for the adsorption of water, ethanol, propanol-1, butanol-1, and cyclohexane on the furnace carbon black Spheron-6 were determined at 25° C. as were also those for the adsorption of water, and propanol-1 on the deflocculated artificial graphite DAG-1. These isotherms are used together with the adsorption theory to predict adsorption isotherms in the solution-adsorbent systems water - propanol - 1 - Spheron - 6, water-butanol-Spheron-6, ethanol-cyclohexane-Spheron-6, and water-propanol-1-DAG-1. Calculated isotherms are compared with experimental isotherms observed by R. P. Craig and R. D. Hansen in this laboratory. With the exception of the system water - butanol - 1 - Spheron - 6, agreement between theory and experiment is at least qualitatively satisfactory, and the theory accounts for puzzling phenomena such as adsorption inversion in a satisfactory manner.

Agreement between theory and experiment is made nearly quantitative in the water-alcohol-Spheron-6 systems by adding to the alcohol Polanyi potential an energy of interaction with an oriented water dipole layer at the adsorbent surface. Arguments justifying this procedure are presented.

Data of Arnold for the system oxygen-nitrogen-anatase are re-interpreted in an effort to test the application of the adsorption theory to mixed gases. Total adsorption predictions agree quantitatively with experiment; the unmodified theory is found

underestimate the adsorption of nitrogen
and to overestimate the adsorption of oxy-
gen. This discrepancy is ascribed to
superposition of adsorption at solid-liquid
and liquid-gas interfaces; no satisfactory
method for correcting for this effect ap-
pears to exist at present.

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## RETURNS TO SCALE IN POTATO FARMING[1]

### IRVING FORBES FELLOWS[2]
Department of Economics and Sociology

The economic theory which is applicable
the production process on the farm firm
emphasized two interrelated problems.
The first is concerned with the optimum
combination of factors to obtain a given
output. The second is concerned with the
optimum adjustment in factor inputs to
variations in outputs. The latter problem
one of evaluating returns to scale.

The primary objective of this study was
estimate the returns to scale in potato
production in Connecticut. In achieving
this objective, the secondary objectives of
collecting, analyzing, and utilizing input-
output data to determine the optimum com-
bination of resources were accomplished.
In the past, economic studies of the re-
lationship between size of enterprise and
efficiency of production have confounded
the influence of size with the influence of
other variables. Farmers have not known
the influence of size upon their farm busi-
nesses. The methods used in this study
permitted control of variables which are
often confounded with size of business.
Through the use of budgets for hypotheti-
cal resource combinations, only those
variables which were directly related to
size were allowed to vary.

In the development of farm budgets, it
was necessary to select at least one fixed
factor with which to specify the size of
each hypothetical farm unit. The quantity
of the regular labor force available during
the production period was selected as this
fixed factor. Five levels of the fixed re-
source were selected for study. All other
resources were permitted to vary. Al-
ternative resource organization and pro-
duction techniques were tested on each
unit to determine the optimum cost posi-
tion, when all phases of the production

activity were carried on as efficiently as
possible under given technology and price
relationships.

Once the physical inputs and production
techniques were determined for each farm
unit, an approximation of the short-run
average unit cost curves was derived.
Next, the long-run cost curve, which in-
dicated the economies associated with size
of enterprise, was constructed.

The scale curve developed in this study
covered an annual production range from
approximately 6,000 to 75,000 bushels of
potatoes. Under the level of management
efficiency visualized for this study, less
than a full man-equivalent in regular labor
was needed in the range under 22,000
bushels. A full man-equivalent or more
was required in the range above 22,000
bushels.

The cost per bushel of potatoes declined
20 percent as annual production increased
from 6,000 to 40,000 bushels. Beyond
this size, the reductions in unit cost were
small. With the production relationships
and institutional conditions assumed for
this study, costs per bushel fell only 2
percent in the range from 40,000 to 75,000
bushels. Thus, size of enterprise was an
important factor in reducing unit costs up
to 40,000 bushels annually. Beyond this
size, unit costs were influenced only to a
minor extent by increases in size of en-
terprise.

The level of unit costs was defined only
for the assumed conditions. Input-output
date were obtained from physical scien-
tists and from an analysis of actual pro-
duction methods on farms. The prices
used were those for the 1949 production
period. The level and shape of the scale
curve would change with changes in these
assumptions. However, there is leeway
for some variation in the assumed condi-
tions without nullifying the following con-
clusions:

(1) Operators of one-man farm units
achieved a unit cost level approximately
equal to the level on farms of larger size
when a similar level of management effi-
ciency was achieved. Operators of farms

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[a]. Chairman of Committee, Earl O. Heady,
    Dept. of Economics and Sociology.
[b]. Doctoral Thesis No. 1327. Submitted
    July 18, 1952.
[a]. B.S. University of Connecticut,
    Storrs, Conn., 1937.
    M.S. Ibid., 1940.
[b]. Graduate Assistant, Dept. of
    Economics and Sociology.

on which the labor resource was less than
a full man-equivalent did not achieve a unit
cost level similar to the level on larger
farms, unless the labor and management
returns to the operator or returns to other
owned resources were substantially below
such returns to operators of larger farms.

(2) Small, or non-existent, economies of
scale in the upper size range indicated
that opportunities for lower unit costs from
specialization of labor and management
and from a lower investment-output ratio
did not occur in potato production as it was
organized in New England under existing
technology. Furthermore, the production
facilities necessary to potato production
were sufficiently variable in size and re-
lated price schedule so that costs were
not lowered substantially by a more com-
plete utilization of indivisible production
elements.

Secondary objectives of this study were
to develop production data which would be
useful to the individual operator. The
study indicates that unit costs could be
lowered substantially by improved resource
organization and production practices on
potato farms--large or small. This re-
port demonstrated the resource organiza-
tion and management practices that con-
tributed to greater efficiency in potato
production, and it established a goal in
the level of production costs under ideal
conditions. Some potato growers could
attain such efficiency; most of them could
move in that direction.

In accomplishing the primary and sec-
ondary objectives, the technique used in
this study evolves as a useful tool in the
establishment and in the integration of
basic relationships. The method serves
the farm operator and the farm manage-
ment technician in the following ways:

(1) It indicates the unit cost reduction
opportunities that are attributable directly
to a change in the size of the enterprise.

Other sources of variation in costs whic
arise largely because of differences in th
quality of resources and management ar
largely eliminated between farms of vari
ous size by using resources of identic:
quality and by employing production or
ganizations and practices which result i
a similar level of management efficiency

(2) Determination of unit costs neces
sitates the collection and appraisal
input-output data in potato production
This step serves to integrate the availabl
information and to uncover the gaps in th
physical data. One can then appraise ho
well the existing data help to answer th
economic problem of allocating scarce re
sources between alternative uses in
maximizing process.

(3) The technique indicates the combi
nation of resources and practices that wi
lead to maximum efficiency at variou
sizes of enterprise under specified condi
tions. Such knowledge is useful to farm
ers. It sets up a goal of efficiency wit
which operators can compare their pre
sent situations, and it indicates possibl
practices in organization and managemer
that may lead to improved efficiency.

(4) The method provides the farm man
agement analyst with a much needed ex
perimental device. The models can b
used to test the influence of a particula
variable when many other variables ar
held constant. In this way, the farm man
agement worker is able to fulfill a majo
responsibility to farmers by anticipatin
management problems and by arriving a
possible solutions. No longer must h
wait until many farmers have made a de
cision and have committed productive re
sources for future periods. The basi
aim of science is prediction and control
Creation of the farm units needed in esti
mating economies of scale provides a too
for realizing this goal in farm manage
ment.

# DISTRIBUTION OF KRONECKER PRODUCTS OF MATRICES[1]

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Department of Mathematics

Let $K = X \cdot Y = (y_{ij}X)$ denote the Kronecker product of two square real matrices X and Y of orders $s > 1$ and $r > 1$, respectively. Let W be the set of all square matrices of order $n = rs$, P the set of all K's of order n, and $P(s, r)$ the subset of P obtained when s and r are fixed. W, P, and $P(s, r)$ be represented in dimensional Euclidean space by the int sets $E_w$, $E_p$, and $E_p(s, r)$, respectively.

Theorem: $E_p$ is an arcwise connected and the intersection of $E_p(s, r)$ with any hypersphere centered at the origin is an arcwise connected set. Furthermore, the intersection of $E_p(s, r)$ with any closed hyperspherical neighborhood of the origin a closed and connected set.

For A in W and K in P, let $F = tr(A-K) \cdot (A-K)'$ and let R be a positive constant.

Theorem: For any fixed A in W, the absolute minimum of F, min F, and a closest K can be obtained by applying the methods of the calculus. Furthermore, r the set of A's for which $\|A\|^2 = AA' = R^2$,

$$\max (\min F) \leq (1 - 1/r^2)R^2.$$

$r \leq s$, then the equality sign holds. The simultaneous algebraic equations be solved for min F and the closest K for a given A are derived for the case $= 2s$. Explicit formulas are obtained

for the cases (1) A is symmetric, and (2) $A = $ diagonal $(A_1, A_2)$ where $A_i$ is s by s.

The given matrix A may also be interpreted as determining $p(\leq r^2)$ points in a $q(\leq s^2)$-dimensional space. The problem of determining min F and the closest K is equivalent to the problem of finding a ray through the origin such that the sum of the squares of the distances from the p points to the ray is a minimum.

Theorem: If $q \leq p$, the matrix A can be written as the sum of q or less distinct Kronecker products by successive determination of $K_1, K_2, \ldots, K_q$, where $K_i$ is closest to $A-K_1-K_2-\ldots-K_{i-1}$; if $p < q$ a trivial decomposition into p summands exists.

Using the above interpretation, let H be the positive definite symmetric matrix which represents the ellipsoid of inertia, centered at the origin, and generated by the p points of unit mass (assumed noncollinear with the origin) determined by A. Let $c_i$ be a characteristic root of H.

Theorem: If $p \geq q$, then only those H's whose characteristic roots satisfy the conditions

$$\sum_{\substack{i = 1 \\ i \neq j}}^{q} c_i - (q-2)c_j \geq 0 \qquad j = 1, 2, \ldots q$$

will represent ellipsoids of inertia. If $p < q$, then the equality sign must hold for at least q-p of the above conditions. Furthermore,

$$(q-1) \ \|A\|^2 \geq \|H\| \geq (q-1) \ \|A\|^2 / q^{1/2}.$$

Finally, for any set of p particles, whose polar moment of inertia is $R^2$, the smallest characteristic root of H is less than or equal to $(p-1)R^2/p$.

## INHERITANCE OF RESISTANCE TO TWO RACES OF CROWN RUST IN OATS[1]

### RALPH E. FINKNER[2]
Departments of Agronomy and of Botany and Plant Pathology

Crown rust of oats caused by the fungus Puccinia coronata avenae Eriks. and E. Henn. has caused severe reduction in yields in some seasons. Recent changes in the prevalence of important physiologic races of this organism clearly emphasize the dynamic nature of breeding for crown rust resistance in oats. The presence of two sets of genetic factors, those carried by the organism and by the host plant, stress the importance of a combined attack on disease resistance by the plant breeder and plant pathologist. The production of new races and biotypes within races through hybridization and mutation makes the task of maintaining effective resistance to prevalent races a difficult one.

Fundamental studies on the inheritance of resistance to crown rust in oats have been somewhat limited. Published information generally has resulted from studies involving a limited number of races and only a few resistant parents. Host-parasite relationships involving crown rust represent a delicate balance between genotypes of both the host and pathogen. It might be expected, therefore, that opportunity for complex gene interaction would occur, with different genes or a combination of different genes determining resistance to various forms of crown rust.

The mode of inheritance of reaction to races 57 and 109 of crown rust was studied in several oat crosses. Conclusions drawn on the basis of the reaction of segregating progenies are summarized below.

1. The resistance of Clinton to race 109 was conditioned by a single dominant gene (AA). Clinton exhibited only reces-

sive alleles to factors for resistance whe[n] tested to race 57.

2. The resistance and susceptibili[ty] of Ukraine to races 57 and 109, respe[c]tively, was governed by the same ge[ne] (MM).

3. Two dominant linked genes de[-] termined the resistance of Santa Fe [to] both races. The genes $(M_1 M_1 U_1 U_1)$ wer[e] linked in the coupling phase with $28.8 + 0.$ per cent recombination. One of the dupl[i-] cate linked genes $(M_1 M_1)$ was allelic to t[he] genes (MM) in Ukraine while the Ukrai[ne] gene (MM) was dominant to $(M_1 M_1)$.

4. Trispernia appeared to posse[ss] two factors $(M_2 M_2 V_1 V_1)$ which gave resi[s-] tance to both races. One of the genes w[as] allelic to the Victoria gene (VV).

5. The resistance of Landhafer [to] both races was observed to be due to [a] single partially dominant factor. Th[e] factor (LL) was epistatic to the Ukrai[ne] gene for susceptibility when tested to ra[ce] 109.

6. A single partially dominant gen[e] (KK) conditioned the resistance of Kle[in] 69b to both races. However, the Ukrai[ne] gene inhibited the resistant reaction [of] Klein 69b when tested to race 109.

7. The resistance of Victoria [to] both races was governed by a single dom[i-] nant factor (VV), which appeared to [be] epistatic to one of the two linked genes [in] Santa Fe, and dominant to the gene $(V_1 V$ in Trispernia. Inheritance of reaction [of] H. victoriae was shown to be monogen[ic] with susceptibility dominant and complete[ly] linked with the Victoria type of crown ru[st] resistance.

8. Several varieties and selection[s] commonly used as resistant parents [in] breeding for crown rust resistance appea[r] to represent mixtures of genotypes. Di[f-] ferent selections from these parents ma[y] possess from one to three factors for r[e-] sistance.

9. Results of this study were com[-] bined with results of previous investiga[-] tions in an effort to catalogue some of t[he] genes determining resistance to crow[n] rust.

# COMPOUNDS OF THORIUM WITH TRANSITION METALS OF THE FIRST PERIOD[1]

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Department of Chemistry

The compositions and structures of the phases obtainable at room temperature in binary systems of thorium with the transition metals of the first period have been determined by X-ray diffraction methods and are summarized in Table 1. The compositions of these intermetallic compounds bear little relation to the customary valences of the metals. Attempts to correlate these compounds with one another and with intermetallic compounds in general have been based essentially upon a consideration of the relative values of metallic radii and upon the ratio of valence electrons to atomic nuclei.

A study of the Laves phases, common in many compounds with the formula $AB_2$ and a radius ratio of approximately 1.25, suggests that it is the A-B distance which determines the size of the polyhedra comprising the unit cell. Inspection of the lattices and coordination polyhedra of the compounds, $ThMn_{12}$, $Th_2Fe_{17}$, $Th_2Co_{17}$, $Th_2Ni_{17}$, and $ThNi_5$, shows that they are related to one another though the compounds belong to different crystal classes.

It appears that the compounds, $ThMn_{12}$, $Th_6Mn_{23}$ and $ThMn_2$, are related to the Hume-Rothery $\beta$, $\gamma$ and $\epsilon$ phases, with electron to atom ratios of 1.5, 1.615 and 1.75 on the basis of Hume-Rothery's valences or with the ratios of 4.94, 4.82 and 4.69 on the basis of Pauling's valences. However, only Pauling's ratios give a consistent value for the valence of manganese. It also appears probable that the compounds in the thorium-iron, thorium-cobalt and thorium-nickel systems are Hume-Rothery type compounds.

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1 a. Chairman of Committee, R. E. Rundle, Dept. of Chemistry.
   b. Doctoral Thesis No. 1299. Submitted May 21, 1952.

2 a. B.Ch.E. The College of the City of New York, 1947.
   b. Graduate Assistant, Institute of Atomic Research.

Table 1.  Compounds of Thorium with Transition Metals of the First Period

| Compound-Space Group Lattice Constants (Å) $a_0, c_0$ | Compound-Space Group Lattice Constants (Å) $a_0, b_0, c_0, \beta$ | Compound-Space Group Lattice Constants (Å) $a_0, b_0, c_0, \beta$ | Compound-Space Group Lattice Constants (Å) $a_0, b_0, c_0$ |
|---|---|---|---|
| | $Th_7Fe_3^{d} - C_{6v}^4$<br>9.85, 6.15 | $Th_7Co_3^{d} - C_{6v}^4$<br>9.83, 6.17 | $Th_7Ni_3^{d} - C_{6v}^4$<br>9.86, 6.23 |
| | | $ThCo^{h} - D_{2h}^{17}$<br>3.74, 10.88, 4.16 | $ThNi^{i} - D_{2h}^{16}$<br>14.15, 4.31, 5.73 |
| $ThMn_2^{a} - D_{6h}^4$<br>5.48, 8.95 | $ThFe_3^{e} - D_{3h}^1$<br>5.22, 24.96 | $ThCo_{2-3}^{e} - D_{6h}$<br>5.03, 24.54 | $ThNi_2^{j} - D_{6h}^1$<br>3.95, 3.83 |
| $Th_6Mn_{23}^{b} - O_h^5$<br>12.523 | $ThFe_5^{f} - D_{6h}^1$<br>5.13, 4.02 | $ThCo_5^{f} - D_{6h}^1$<br>5.01, 3.97 | $ThNi_5^{f} - D_{6h}^1$<br>4.97, 4.01 |
| $ThMn_{12}^{c} - D_{4h}^{17}$<br>8.74, 4.95 | $ThFe_{17}^{g} - C_{2h}^3$<br>9.68, 8.56<br>6.46, 99°20' | $Th_2Co_{17}^{g} - C_{2h}^3$<br>9.62, 8.46<br>6.32, 99°6' | $Th_2Ni_{17}^{k} - D_{6h}^4$<br>8.37, 8.14 |

[a]Structure C14 type (Strukturbericht designation).

[b]Structure: 24(e) Th with x=0.203; 4(b) Mn; 24(d) Mn; 32(f) Mn with x=0.378; 32(f) Mn with x=0.178 (all point groups as listed in "Internationale Tabellen zur Bestimmung von Kristalstructuren", Erster Band, Gebrüder Borntraeger, Berlin, 1935).

[c]Structure: 2(a) Th; 8(f) Mn; 8(i) Mn with x=0.361; 8(j) Mn with x=0.277.

[d]Structure reported by N.C. Baenziger, "The Crystal Structure of Some Thorium and Uranium Compounds," unpublished PhD. Thesis, Ames, Iowa, Iowa State College Library, 1948.

[e]Structure unknown.

[f]Structure $CaZn_5$ type $D2_x$ (Strukturbericht designation).

[g]Structure postulated: 4(i) Th with x=0.167 and z=0.333; 8(g) Fe with x=0.360, z=0.333; 8(j) Fe with x=0.417, y=0.250, z=0.333; 4(g) Fe with y=0.140; 4(c) Fe; 4(i) Fe with x=0.167, z=0.333; 4(i) Fe with x=0.416, z=0.147; 2(d) Fe.

[h]Structure: 4(c) Th with y=0.136; 4(c) Co with y=0.416.

[i]Structure: 4(c) Th with x=0.094, z=0.140; 4(c) Th with x=0.344, z=0.140; 4(c) Ni with x=0.268, z=0.630; 4(c) Ni with x=0.518, z=0.870.

[j]Structure C32 type (Strukturbericht designation).

[k]Structure postulated: 2(b) Th; 2(c) Th; 6(g) Ni; 12(j) Ni with x=0.333, y=0; 12(k) Ni with x=0.167, z=0; 4(f) Ni with z=0.11.

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### SOME CYTOGENETIC ASPECTS OF MAIZE MONOPLOIDS AND MONOPLOID DERIVATIVES[1]

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The specific problem in this study was to examine the cytogenetic aspects of maize monoploids and monoploid derivatives.

For the study of diploid derivatives of monoploids, 186 different progenies consisting of 1,289 mature plants from crosses involving one or more monoploids, homozygous diploids, and standard inbreds were grown at Iowa State College experimental plots.

Microsporocytes were examined by means of fresh aceto-carmine smears. Each plant was also examined for visible mutations and pollen sterility.

The hybrids of 58 progenies of tester x homozygous diploids, a total of 555 mature plants, showed seven plants with pollen sterility in two progenies, but no structural aberrations were noted.

The hybrids of 12 progenies of tester x inbreds, a total of 130 plants, showed

three plants with pollen sterility in one progeny, each plant having a structural aberration.

No observable mutations appeared in either group of hybrids.

The study indicates quite strongly that the homozygous diploids have no more structural heterozygosity, no more pollen sterility, or no higher mutation rate than the inbreds, hence in these respects would be just as satisfactory in a breeding program.

Miscellaneous crosses involving monoploids as male and female parents together with normal diploids showed very little pollen sterility or cytological irregularity.

Five monoploids appeared in the 1,171 plants reaching maturity in stocks arising from monoploids as one or both parents, an incidence of 1:234.2.

Monoploid meiosis was studied in fifty plants and the following noted: chiasma-formation, bivalents, homologous vs. non-homologous pairing, pachytene doubleness, apparent secondary association, irregular spores, foldbacks, bridges and fragments.

Probably most viable monoploid pollen arises from diploid sectors, but some viable eggs may arise from monoploid tissue. If so, and if true crossing over does occur, then the homozygous diploids may not be completely homozygous.

## NATURE AND INHERITANCE OF MALE-STERILITY
## IN THE ONION VARIETY, SCOTT COUNTY GLOBE₁

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⊓rom a cross made in 1941 at Belts-
-:, Maryland, Dr. H. S. Jones of the
⁚. Department of Agriculture observed
⌐-e-sterile onion plants, although none
⠿ e expected. Neither parent had any
⌐⌐rd of male-sterility in its parentage.
⁊i female parent was a male-fertile Scott
⌐nty Globe plant and the pollen parent
⁚⁝ from an F₄ generation of a cross be-
⁚en plants of the varieties Australian
⁚wn and White Persian. Of the 11 plants
⁚wn, five male-fertile plants and six
⁚⁚e-sterile plants appeared in the progeny.
⁝:male-sterile plants were crossed with
⁚ious fertile plants and the normal plants
⁚ m the same progeny were selfed. The
⁚ d lots from these crosses and selfed
⁚nts were used as the original material
⁝ m which this investigation was based.
⌐his investigation was undertaken be-
⁚se of the utilization of male-sterility
⁚producing hybrid onions. The type of
⁚le-sterility used is expressed only
⁚en an S type of cytoplasm (maternally
⁚erited) and a simple recessive gene
⁚ are both present. The S cytoplasm
⁚ s found in a plant of the variety Italian
⁚d and has been introduced into the
⁚mmercially used inbred lines, none of
⁚ich have been found to otherwise con-
⁚n the type of cytoplasm necessary for
⁚pression of male-sterility. The ms
⁚ne, however, has been found in almost
⁚l varieties.
⁚In this investigation a study was made
⁚ the inheritance of this male-sterility
⁚ observing segregation in the progen-
⁚s received from Beltsville, Maryland,
⁚d by making two types of test crosses.
⁚he test crosses made were 1) between
⁚ale-sterile plants and plants containing
⁚rmal cytoplasm with the ms gene in
⁚e homozygous condition and 2) between
⁚rmal plants with the Scott County Globe
⁚ale-sterile cytoplasm and male-ster-

ile plants with the Italian Red type of
male-sterility. The normal plants were
selfed at the same time that they were
crossed. The observed segregation in
the original material as well as the ob-
served segregation in the progenies of
the test crosses indicated that the male-
sterility in the material investigated was
not only inherited in the same manner as
the Italian Red type of male-sterility,
but also that the genes were allelic.
Likewise, the progenies of these crosses
indicated that the cytoplasmic factor gov-
erning the expression of male-sterility in
the material investigated was the same as
that found in the Italian Red type of male-
sterility.

There are suggestions in the segregation
for male-sterility and degree of fertility
among the progenies of some of the cros-
ses that the indicated manner of inherit-
ance is modified by other genes. One
suggestion appears in the wide range of
percentages of viable appearing pollen
found among plants heterozygous for the
ms gene. Another suggestion comes from
the unexpected manner in which segrega-
tion for male-sterility occurred in a few
closely related progenies.

Seed heads from three male-sterile ap-
pearing plants in which no viable appear-
ing pollen was found, two sterile appearing
plants in which low percentages of viable
appearing pollen were found, and one nor-
mal appearing plant containing low per-
centages of viable appearing pollen from
a progeny which was expected to be com-
posed of only male-sterile plants, were
kept in separate cages to exclude foreign
pollen. All seed heads, except those from
the sterile appearing plants in which no
viable appearing pollen was found, pro-
duced small amounts of seed.

.A study of microsporogenesis within
the anthers of both normal and male-
sterile plants was also made. Pollen
grain and tapetum development appeared
to be the same in both Nmsms plants and
SMsms plants. Microspore degeneration
in male-sterile plants of the material
under investigation appeared to be the
same as that in male-sterile plants of the
Italian Red type, as previously reported.
The tapetal fluid found surrounding the
microspores in normal anthers was either
lacking or nearly lacking in all developing
anthers of male-sterile plants observed.

## PROFILE PROPERTIES OF THE GALVA-MOODY SOIL SEQUENCE OF NORTHWEST IOWA[1]

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In the northwestern part of Iowa there is an area covering about six to seven counties that is almost continuously covered with loess which rests directly on the calcareous Iowan or Tazewell drift. The loess thins from about 140 inches to 40 inches in an easterly direction. The annual precipitation increases from about 25 to 29 inches in a southeasterly direction. Six profiles, belonging to the Galva and Moody series and representing well drained loess derived soils formed on 3 to 4 percent slopes, were studied in the field and laboratory. The profiles were selected along two traverses which represent soil development under increased annual precipitation or under increased annual precipitation and decreased loess thickness. Greater profile development was associated with increased annual precipitation and decreased loess thickness.

In the field, greater profile development was associated with slightly darker and thicker $A_1$ horizons, greater structural development in the B horizon and a sharper color contrast between the B and C horizon.

Physical changes associated with increased profile development include greater amount of clay in the solum, increased aeration and total porosity and increased permeability and water storage. A characteristic feature of the soils was the occurrence of the maximum percent of inorganic colloids in the $A_1$ horizon. This was taken to mean that con-

ditions for weathering and clay formation were most favorable in that zone and that clay movement has not been extensive.

Chemical changes associated with increased profile development were decreased pH, decreased base saturation, increased amount of exchangeable calcium and hydrogen, increased calcium to magnesium ratio, and increased organic carbon and total nitrogen. The maximum amount of exchangeable hydrogen occurred in the surface layer, of calcium in the subsurface layer, and of magnesium in the first to third layer below the subsurface layer. All sola showed diffusion pattern with depth for pH, base saturation, organic carbon, total nitrogen, and carbon to nitrogen ratio. Exchangeable potassium and release of nonexchangeable potassium to Dowex-50 were no clearly related to increased profile development. Ammonium fixation in nonexchangeable form under moist conditions occurs in the Galva and Moody soils to an extent of about 5 to 8 percent of the cation exchange capacity. A comparison of ammonium fixation in the Moody with that in the highly weathered Putnam of Missouri indicates that there is relatively more illite and less montmorillonite in the Moody soil.

The classical separation of the Chernozems and Brunizems was based primarily on the presence of a lime accumulation layer in the former and its absence in the latter. It has been pointed out more recently that soils with or without a lime accumulation layer occur in what was formerly considered to be areas of Pedocal and Pedalfer soils. On the basis of present concept, the Galva and Moody profiles investigated belong to the Brunizem great soil group even though the two Moody profiles studied had a lime accumulation layer at 31 inches.

## ESTIMATION BY SIMULTANEOUS EQUATION
## OF RESOURCE PRODUCTIVITIES FROM TIME SERIES
## AND CROSS SECTIONAL FARM OBSERVATIONS[1]

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Department of Economics and Sociology

the main objective of this study was to estimate resource productivities of a group of central Iowa farms by two meth-[?]

(1) simultaneous equations,
(2) single equation-least squares.

A dynamic economic model was specified to describe the behavior of farm operators in their production operations. It is designed to explain the annual fluctuations in the quantities of crops and livestock produced by these individual farms, and the quantities of the factors of production employed in the transformation ocesses. The model was simplified by assuming that two independent systems existed: (1) cropping system and (2) livestock system. Each system included five equations; the production function and four precision functions.

The equations presented expressed the relationship among the variables specified. These variables were described in detail and classed as jointly dependent, the formation of which is to be explained, and predetermined, those variables that influence the jointly dependent variables but are not influenced thereby.

Estimation of the parameters in the production functions by the use of simultaneous equations utilizes all of the variables in the system whether they enter the equation to be estimated or not. The single equation-least squares method of estimation utilizes the information provided by the variables that enter the equation to be estimated.

Data used to represent the cross section, inter-farm, variables was obtained from Farm Management Association record summary sheets for a sample of 18 central Iowa farms. Restrictions placed upon the sample were that the farms maintained

the same size and the same operator for the ten year period under study. Thus each farm for a particular year was considered as an independent observation, with a "sample" size of 180. Time series data was constructed from the Iowa Crop Reporting Service records.

The parameters of the production functions, algebraic functions linear in the logarithms, were then estimated by the single equation-least squares method of estimation and the limited information method. There appeared to be no degree of comparability between the parameters obtained by the two methods. The least squares method seemed to provide the more acceptable estimates.

The marginal productivities and average productivities were computed for both systems at the average value of the observed data. Analysis of the productivities obtained by both methods of estimation exhibited a great variation between the estimates of the productivities within each system, between the two systems, and between the two methods of estimation. The greater variation was found in the estimates made by the limited information method.

No definite conclusion as to the superiority of either system was attempted from the empirical results. Possible points of criticism that might improve the estimation are improvements of the dynamic model to be constructed, with the main criticism being on the assumption of independence between the two systems, and refinement in the data used to construct the variables. Before any conclusive reports may be made, other algebraic forms of the production functions should be used, e.g., an equation that is linear in the observed variables, or mixed logarithmic and linear forms.

Employing other models may improve the estimations of the parameters. Before estimations may be made from data drawn from a sample of farms and inferences drawn for a population of farms, more positive conclusions must be presented as to the statistical method to use the model to employ. The present results might mean a complete misuse of research funds in terms of the value received by the group for whom the estimates are made.

## EFFECT OF INSECTICIDES ON CUCURBIT INSECTS AND PLANTS[1]

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Experiments were conducted for four years to determine the effect of several insecticides applied as sprays and dusts on the insects associated with cucurbits and to determine the effects on the plants themselves. The dusts were applied by means of a rotary hand duster and the sprays by a knapsack sprayer. In all, 17 dusts and 21 sprays were tested. Experiments on muskmelons were made at Muscatine Island Field Station, Fruitland, Iowa, and the other experiments at Ames, Iowa. The insects of primary concern were the striped cucumber beetle, Acalymma vittata (Fab.); spotted cucumber beetle, Diabrotica undecimpunctata howardi Barb.; squash vine borer, Melittia cucurbitae (Harr.); squash bug, Anasa tristis (DeG.); and melon aphid, Aphis gossypii Glov.

During the period covered by this study, the infestation of cucumber beetles was light on Muscatine Island. Bacterial wilt of cucurbits, which is transmitted by cucumber beetles, was greatly reduced in muskmelon plots by heptachlor, EM 25-3 and purified DDT. Plots of muskmelons treated with purified DDT, methoxychlor, aldrin, lindane and heptachlor usually produced high yields although the differences were not of statistical significance. The insecticides did not have any effect on the maturity date of the muskmelon fruit. Dieldrin, aldrin, chlordane, BHC and EPN reduced the amount of injury by the larvae of the cucumber beetle to the rind of the muskmelon fruit. The effect on plant growth was determined by measuring the diameter of randomly selected plants from each plot. Penfluor, toxaphene, and BHC were so phytotoxic that their use for insect control was ruled out. A number of the insecticides stimulated growth of the plants. Rotenone and purified DDT mixed in varying portions showed the amount of vine growth to be proportional to the amount of DDT used; however, there were no statistical differences in yield. With all com-

pounds tested, there was a significant increase in yield between plants treated every three days and those treated every seven days. Plants treated for six weeks yielded no more than those treated for three weeks. Many more plants in plots of the variety V-1 were killed by cucurbit wilt than were killed in plots of five other varieties examined.

On three varieties of squash, actual counts were made of the striped cucumber beetle population following treatment with insecticides. All the materials tested proved effective in reducing the beetle numbers; however, when the number of seedling plants injured by beetle feeding were counted, EM 25-3, purified DDT and methoxychlor were found to have given the best control.

The squash bug population was determined by placing strips of tarred felt beside the base of the squash plants. The bugs collected under these strips in the evening and were counted early the next morning. Metacide and EM 25-3, both of which contained parathion, proved the most effective in reducing the squash bug infestation.

Melon aphids were controlled with metacide, lindane, heptachlor, and EM 25-3. Purified DDT and methoxychlor caused an increase in the melon aphid infestation.

Lindane and dieldrin showed good squash vine borer control while the results with heptachlor, purified DDT, and methoxychlor, were erratic. None of the material tested showed any ovicidal action on squash vine borer eggs. Cl110, a proposed synergist for DDT, failed to show this action when used for control of squash vine borer in summer squash, but the borer population was low and the synergistic action may have become apparent under a heavier infestation.

No off-flavors were detected in squash fruit treated with lindane or heptachlor.

The greatest yield came from squash plants treated with heptachlor, dieldrin and lindane. Yield results with purified DDT were erratic. All of the chemicals tested caused an increase in vine length. The treated plants increased in length more rapidly than the untreated plants early in the growing season, but later the control plants grew just as rapidly as the treated plants. Among the possible factors which may have led to an increase in growth were (1) control of insects and (2) a plant hor-

...like effect of the insecticide. The
m..t of precipitation greatly influenced
growth and tended to mask the effects
.. insecticides. There was varietal
..fference in reaction to the effect of in-
..cides on growth rate of the plants.
..oxychlor caused a decreased rate of
..th in Golden Delicious squash and an
..rease in Buttercup variety. The insec-
..des had little or no effect on the num-
.. of nodes or on the position of the first
..le flower or position of the first fruit
.. squash runner.

..gle runners were so trained in the
.. that initiation and development of
..er buds could be followed. The plants
.. methoxychlor-treated plots of Gol-
..elicious squash produced significantly
.. r female flowers than did the untrea-
.. lants. The rate of feminization along
.. runner was also less in these treated
.. ..

..e insect population of squash flowers
.. determined several times during the
..on. Five species of diptera, five spe-
.. of coleoptera, and 15 species of hy-
..optera were collected during this time.
.. number of wild and domestic bees was
.. rsely proportional to the number of
..ted and striped cucumber beetles pre-
.. .. The bees seemed to avoid entering
..ers inhabited by beetles.

.. n approximate rate of photosynthesis
.. determined by measuring the gain in
..ght per unit area of squash leaf during
.. ours of daylight. The reaction of the
..ash varieties to the insecticides varied
.. atly. The photosynthesis rate in metho-

xychlor-treated Golden Delicious squash
declined steadily in relation to the rate in
the other insecticide treated plants. In
Buttercup variety, however, methoxychlor-
treated plants always had a higher photo-
synthesis rate than the other treated plants.

Summer squash grown in plots receiving
various amounts of commercial fertilizer
showed no relationship between fertility
level and damage by the striped and spot-
ted cucumber beetle or in the egg laying
preference of the female squash vine borer.
The establishment of the vine borer larvae
in the vines, however, was directly pro-
portional to the amount of fertilizer ap-
plied to the plot.

Two unusual plant injuries of unknown
etiology are noted and figured.

Fourteen dusts were applied to water-
melon grown at the Muscatine Island Field
Station for a study of striped cucumber
beetle control but a heavy infestation of
Fusarium wilt prevented obtaining satis-
factory data.

The area of new growth that a plant
makes after an insecticide has been ap-
plied is left unprotected from insect at-
tack. To get an estimate of this area,
measurements of runner elongation and of
increase in leaf area were made on one
untreated variety each of squash, pumpkin,
muskmelon, watermelon, and cucumber.
Squash and pumpkin had the highest rate
of growth and thus the greatest unprotected
area, while cucumber and muskmelon had
the least amount of growth and least un-
protected area.

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## SEX DEVELOPMENT IN DROSOPHILA MELANOGASTER AS INFLUENCED BY A GENE IN THE THIRD CHROMOSOME[1]

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Department of Genetics

In 1942, a dominant sex-limited gene
(r) causing hermaphroditism was isolated
.. our laboratory. This gene is in the
.rd chromosome of <u>Drosophila melano-</u>
<u>aster</u>. It produces no effect on the via-

bility and fertility of the males, but dip-
loid females carrying it develop into her-
maphrodites which are sterile. The fact
that it causes complete sterility in fe-
males, coupled with the fact that there is
no crossing over in the males, makes it
impossible to obtain the exact location of
the gene within the third chromosome.

The effect of this gene is first visible in
the second instar larvae, indicating that
the time at which the gene acts is very
early in larval development. Adult her-
maphroditic flies resemble diploid females
in body size and form. The anal valves
are often displaced and possess both dor-

soventral and lateral clefts. Below the anal valves are a pair of abnormal clas- pers, which are supported by irregular plates. Between the anus and the sternite, a large irregularly-shaped, heavily pig- mented and sclerotized protuberance is generally found. This knob represents the rudimentary vulva or the posterior part of the female genitalia and often carries sper- mathecae. All hermaphrodites have sex combs on the basal tarsal segment of each foreleg. The comb consists of seven or eight teeth instead of the usual ten found in normal males. The presence of modi- fied sex combs indicates that the first tar- sal segments of the forelegs of the herma- phrodites are composed of some male tis- sue, which can evoke the sex comb form- ing capacity. Morphologically, the inter- nal genitalia exhibit great variability, yet in no case is a complete sex reversal found. Each specimen represents a dis- tinct degree of mixture of male and female parts, either rudimentary or well devel- oped. In cases where genital ducts of both sexes are present, vasa efferentia as well as part of the ovarian tissue are yel- low pigmented. This suggests that the hermaphroditic gonads have the potentiality of developing the yellow pigment of the testicular epithelium as well as retaining the unpigmented condition of the ovary.

Transplantations of normal male and female gonads and of genital discs into hermaphrodites show that the development of both the hosts and donors is autonomous. No sex hormones from the gonads of either

sex were detected. The transplantation of testes into wild type females and of f male genital imaginal discs into wild ty males show that only cellular contact the ovary or the oviduct to the testes w cause degenerative changes of the latte It is obvious that some antagonistic pri ciple must be present in the normal ova or the oviduct that causes degenerati reduction of the male testes.

Transplantations of normal male a female ring glands into the hermaphrodit accelerate the growth and differentiati of the gonads and accessory organs to considerable extent. The result indicat that a nonautonomous development oc curs. The ring gland of normal genet constitution must release some substan necessary for growth and differentiatic which is lacking in the hermaphroditic i dividuals.

Morphological, physiological, and gen tic studies suggest that the normal allel of the hermaphrodite factor is a sex-di erentiating gene guiding normal . develo ment of the reproductive tract. The he maphrodite gene (Hr) has significant s effects. It retards the growth process the gonad, distorts the hypothetical em bryonic field of the imaginal leg and gen tal discs, lacks the potency to regula the activating agencies of both sexes, an finally, reduces the growth and differen tiation hormone produced by the ring glan In sum, the effects seem to extend to a organs concerned with sexual developmer

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# ELECTRICAL RESISTIVITY AND HALL EFFECT IN SODIUM TUNGSTEN BRONZE₁

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Department of Physics

The electrical resistivity and Hall coef- ficient have been measured for single crys- tals of sodium tungsten bronze ($Na_xWO_3$) as a function of temperature, and as a function of sodium concentration, for val- ues of x between 0.58 and 0.90.

Single crystals of the bronze were pre- pared by heating sodium tungstate, tungstic

oxide, and powdered tungsten, in the pro per proportions, at 1000° C. for sever hours, and then cooling the melt slowly The sodium concentration of the resultin crystals was governed by the proportio of sodium tungstate in the initial mixture Sodium analysis of the crystals was ac complished by an X-ray determination the lattice constant. The x value was the determined from the known relationshi between the sodium concentration and th lattice parameter. The X-ray analyse revealed appreciable amounts of free, me tallic tungsten in many of the crystals The crystals used in the experiments wer about 3 mm. long and about 1.5 mm.² cross-sectional area.

Using a potential method, measurements were made of the resistivity of sodium tungsten bronze in the temperature range 1° K. to 300° K. The low temperatures were obtained in a Collins Helium Cryostat. The room temperature resistivity exhibited a minimum value of $(3.20 \pm 0.14)$ $\times 10^{-5}$ ohm-cm. at $x = 0.75$, in agreement with previous reports. The room temperature resistivity was $(12.5 + 0.23) \times 10^{-5}$ ohm-cm. at $x = 0.584$ and $(5.89 \pm 0.20) \times 10^{-5}$ ohm-cm. at $x = 0.863$.

The resistivity was linear with temperature in the range 125° K. to 300° K. The temperature coefficient of resistivity was also a minimum at $x = 0.75$. The value of the temperature coefficient of resistivity that sodium concentration was $(9.45 + 0.60) \times 10^{-8}$ ohm-cm./°C. The resistivity was very nearly constant below 30°.

The residual resistivity was obtained by extrapolation of the resistivity to absolute zero. A minimum in the residual resistivity was found at $x = 0.75$ where the value of the residual resistivity was $(1.25 + 0.10) \times 10^{-5}$ ohm-cm. The residual resistivity for all concentrations measured was from about one-third to one-half the room temperature resistivity.

The Hall coefficient was measured using an alternating primary current method. The variation of the Hall coefficient was less than 2 per cent with temperature in the range 78° K. to 370° K. The Hall coefficient was inversely proportional to the sodium concentration in the range of concentrations studied. At $x = 0.584$ the Hall coefficient was $-(6.10 \pm 0.15) \times 10^{-4}$ cm.$^3$/ coulomb and at $x = 0.897$ was $-(4.07 \pm 0.03) \times 10^{-4}$ cm.$^3$/coulomb. Within the experimental error the values for the Hall coefficient corresponded to one free electron for each sodium atom in the lattice.

The minimum in the resistivity as a function of sodium concentration is due to an anomalous maximum in the electron mobility at $x = 0.75$. The reasons for this anomaly are not clearly understood.

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# DIFFERENTIAL EQUATIONS IN THE DISTRIBUTION OF SCHWARTZ[1]

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This thesis is an investigation in the recently developed distribution theory of Schwartz (1). The notation used follows that used by Schwartz (1). Greek letters $\varphi$, $\alpha$, $\theta$ ) are used for testing functions, and T denote distributions. The value of T for $\varphi$ is $T \cdot \varphi$.

The equation

$$L(T) \equiv P_0(x)T^{(n)} + P_1(x)T^{(n-1)} + \ldots + P_n(x)T = S,$$

where S is given and each $P_i(x)$ is indefinitely differentiable, is a linear differential equation in distributions of one variable. If $S = 0$, the equation is homogeneous.

Theorem 1. $L(T) \cdot \varphi = T \cdot \bar{L}(\varphi)$, where $\bar{L}$ is the linear differential operator adjoint to L.

Theorem 2. The operator $\bar{L}$ maps the space of testing functions D onto the linear subspace $D_\alpha$, whose elements are $\alpha =$

$L(\varphi)$, continuously in the sense of D.

Theorem 3. The totality of solutions of $L(\overline{T}) = 0$ forms a linear subspace $D'_\alpha$ of the space of distributions. $D'_\alpha$ is the annihilator of D.

Theorem 4. If(a) the mapping $\bar{L}(\varphi)$ has a continuous inverse $\bar{L}^{-1}$, (b) the distributions $T_1, T_2, \ldots, T_n$ are a basis for the subspace of solutions of $L(T) = 0$, and (c) $T_1 \cdot \varphi = T_2 \cdot \varphi = \ldots = T_n \cdot \varphi = 0$ implies that $\varphi$ is an element of $D_\alpha$; then the differential equation $L(T) = S$ admits a unique general solution having the form

$$T \cdot \varphi = \sum_{i=1}^{n} C_i T_i \cdot \varphi + S \cdot \bar{L}^{-1}(\varphi - \sum_{i=1}^{n} c_i \varphi_i),$$

where $c_i = T_i \cdot \varphi$, and the $\varphi_i$ are a set of linearly independent testing functions satisfying $T_i \cdot \varphi_j = \delta_{ij}$.

Theorem 4 is proved with the aid of a well known algebraic theorem (2). Examples are given in the thesis of cases where hypothesis (a) in Theorem 4 is not satisfied.

Using Theorem 4, solutions are obtained for the equations

(a) $T^{(n)} = S$
(b) $T' + f(x)T = S$.
(c) $xT' - \lambda T = S(\lambda$ real$)$

(d) $x^2 T' + T = S$
(e) $x^3 T' + 2T = S$
(f) $x(x - 1)T' + T = S$
(g) $x^2 T'' + xT' - T = S$
(h) $\sin x \; T' + \cos x \; T = S$.

A typical solution is that for (c). The equation $xT' - \lambda \; T' = S$ has the solution

$$T \cdot \varphi = C_1 T_1 \cdot \varphi + C_2 T_2 \cdot \varphi + S \cdot \theta ,$$

where $C_i$ is an arbitrary constant. For values of $\lambda < -1$ and not integral

$$T_1 \cdot \varphi = Fp \int_{-\infty}^{0} |x|^{\lambda} \varphi \;(x) dx,$$
$$T_2 \cdot \varphi = Fp \int_{0}^{\infty} x^{\lambda} \varphi \;(x) dx,$$

and

$$\theta(x) = -\frac{\alpha(x)}{\lambda + 1} - \frac{x \; \alpha'(x)}{(\lambda+1)(\lambda+2)} + \dots$$
$$+ \frac{(-1)^{p-1} x^{p-1} \alpha^{p-1}(x)}{(\lambda+1) \dots (\lambda+p)}$$

$$+ \frac{(-1)^{p} x^{-\lambda} x^{-1}}{(\lambda+1) \dots (\lambda+p)} \int_{-\infty}^{x} |t|^{-\gamma} \alpha^{(p)}(t)(\text{sign } x)^p dt.$$

Here $-\lambda = \gamma + p$, where $p$ is an integer, and $0 < \gamma < 1$. Fp refers to the finite part of an integral (1). The testing function $\alpha$ is given by

$$\alpha(x) = \varphi(x) - c_1 \varphi_1(x) - c_2 \varphi_2(x),$$

where

$$T_i \cdot \varphi_j = \delta_{ij} \text{ and } c_i = T_i \cdot \varphi .$$

for values of $\lambda > -1$,
$$T_1 \cdot \varphi = \int_{-\infty}^{0} |x|^{\lambda} \varphi \;(x) dx,$$
$$T_2 \cdot \varphi = \int_{0}^{\infty} x^{\lambda} \varphi \;(x) dx, \text{ and}$$
$$\theta(x) = -x^{-1} |x|^{-\lambda} \int_{-\infty}^{x} |t|^{\lambda} \alpha(t) dt,$$

$\alpha$ being defined as above. For negative integral values of $\lambda (-\lambda = k)$
$$T_1 \cdot \varphi = \delta^{(k-1)} \cdot \varphi ,$$

$$T_2 \cdot \varphi = Fp \int_{-\infty}^{\infty} x^{-k} \varphi \;(x) dx, \text{ and}$$

$$\theta(x) = \frac{\alpha(x)}{k-1} + \frac{x \alpha'(x)}{(k-1)(k-2)} + \dots + \frac{x^{k-2} \alpha^{(k-2)}(x)}{(k-1)!}$$

$$- \frac{x^{k-1} \ln|x| \alpha^{(k-1)}(x)}{(k-1)!} + \frac{x^{k-1}}{(k-1)!} \int_{-\infty}^{x} \ln|t| \alpha^{(k)}(t) dt.$$

In the definition of $T_1$ above, $\delta \cdot \varphi = \varphi(0)$ is the Dirac distribution.

A solution of the "equation of composi tion"

$$L(\delta) * T = \delta ,$$

where L is a linear differential operato with constant coefficients, is an elemen tary solution of the more general equatio

$$L(\delta) * T = S.$$

Theorem 5 (Schwartz). If the distribu tion E satisfies

$$L(\delta) * E = \delta ,$$

then the distribution $E * B$ satisfies
$$L(\delta) * (E * B) = B,$$

where B is a given distribution.

It is shown in the thesis that to the fun damental solution

$$V(x, t) = \begin{cases} (4\pi \; kt)^{-1/2} \exp(-x^2/4kt), & t > 0 \\ 0 & , \quad t \leq 0 \end{cases}$$

on the theory of heat conduction corres ponds a distribution which is the elemen tary solution of the heat equation

$$k \; \frac{\partial^2 U}{\partial x^2} - \frac{\partial U}{\partial t} = (k \; \frac{\partial^2 \delta}{\partial x^2} - \frac{\partial \delta}{\partial t}) * U = -S,$$

where U is the temperature distribution and S is an arbitrary distributional heat source.

Some solutions of this equation are de rived from the elementary solution by means of the result of Theorem 5, and are found to agree with those in classical litera ture (3).

Finally, an example is given of the sol ution of a boundary value problem involv ing the heat equation in one dimension by a separation of variables method.

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## SUBJECTIVE EVALUATION OF OBJECTIVE QUALITY MEASUREMENTS OF CANNED SWEET CORN[1]

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present, objective tests of sweet corn maturity and quality are used to determine the chemical or physical changes occurring as maturity increases or they determine specific characteristics of a given sample. The use of objective tests and the corresponding subjective evaluation does not take into consideration the limits of the smallest increment of quality change which can be detected by the average consumer.

The objectives of this investigation were: (1) to determine the smallest increment of several variable quality factors of sweet corn, measured objectively, which can be detected subjectively by a panel of competent judges, and (2) to determine the relative importance of the presently accepted objective quality measurements on subjective evaluation.

Twenty-eight sample lots of canned sweet corn were prepared from plantings of the sweet corn variety Iochief. Objective measurements of field and canned moisture content, pericarp content, alcohol-insoluble solids content, and kernel volume were made to determine the quality composition of each lot.

Lot comparisons were submitted to a panel of qualified judges, whose acuity was assumed equal to or greater than average consumers, for subjective evaluation. The panel attempted to distinguish between various combinations of two lots by use of the triangle taste test.

The influence of quality factors other than the one under investigation influenced the decisions of the judges to such an extent that differences between lots could not be distinguished by a single quality factor, such as succulence.

Objective quality factors were so highly correlated that one factor could not be varied independent of other factors sufficiently to obtain all desired combinations for a study of the influence of objective quality factors on subjective evaluation.

An equation representing the effects of the four objective quality measurements

on the subjective decisions of the judges was formulated by the use of the multiple regression technique. Paired sweet corn lots were submitted to the panel of judges for detecting difference on any desired palatability basis. The multiple regression equation computed was:

$$\hat{Y} = 7.64 + .647 X_{cm} + 6.038 X_p + .027 X_a + .622 X_v.$$

The symbol designations are:

$\hat{Y}$ = estimated number of correct solutions.

$X_{cm}$ = difference in per cent moisture between two lots being tested.

$X_p$ = difference in per cent pericarp between two lots being tested.

$X_a$ = difference in per cent alcohol-insoluble solids between two lots being tested.

$X_v$ = difference in volume of 20 kernels, expressed in milliliters, between two lots being tested.

The degree of linear association between the dependent and the independent variables was statistically significant at the ninety-nine per cent probability level, since the coefficient of multiple regression, R, and the F value in an appropriate analysis of variance were significant at that level. The portion of the sum of squares of the dependent variable accounted for by the independent variables was approximately 23 per cent. While four factors accounted for 23 per cent of the variation in number of correct judgements rendered by the panel, they were the commonly accepted quality measurements and it is very likely that a large number of additional factors were involved in influencing the subjective decisions of the judges.

An improvement upon the amount of variation accounted for was attempted since the subjective effects could be nonlinear. This attempt included the addition of factors to a multiple regression equation which equalled the square of each individual term and the addition of factors for the two factor cross products of the objective measurements. No appreciable improvement was made with this approach.

The relative effects of the objective measurements were determined by computation of the standard partial regression coefficients between the objective measurements and the correct judgements of the panel. The proportionate effect was: canned moisture 45 per cent, pericarp 31 per cent, kernel volume 22 per cent, and alcohol-insoluble solids 2 per cent. It

was concluded that moisture was the best criterion for the judging of quality in sweet corn among the objective measurements of pericarp, kernel volume and alcohol-insoluble solids.

The computed regression equation was employed for determination of the increments of various quality factors of sweet corn, measured objectively, which could be detected subjectively. Several statements can be made relative to the computed equation: (1) the dependent variable, $\hat{Y}$, must equal at least nine if 15 tests are conducted; (2) the first term on the right side of the equation should equal five if all of the quality factors had been studied, since five correct solutions would occur by chance; (3) the difference between the first term, a constant, mentioned and the dependent variable, $\hat{Y}$, having a value of nine in this example, equals the quantity required to be accounted for by the independent variables, $X_i$s, in the equation, and (4) a change in any $X_i$, with all other $X_i$s held constant, necessary to make the dependent variable, $\hat{Y}$, equal to nine is the difference increment in the objective quality measurements which can be detected subjectively by the judges who were on the panel used to obtain the regression

equation empirically.

The computed difference necessary ensure detection, at the 95 per cent pro bability level, between canned sweet co lots for each variable measured objectivel and with all others held constant was: 2.1 per cent for canned moisture, 0.23 pe cent for pericarp, 50.37 per cent for alc hol-insoluble solids, and 2.19 ml. per 2 kernels for kernel volume. The minimur difference in objective quality measure ments which could be detected by the ex perienced panel of judges in this investi gation was: 0.52 per cent for moisture 0.06 per cent for pericarp, 0.95 per ce for alcohol-insoluble solids, and 0.68 ml per 20 kernels for kernel volumes.

Verification of the regression equatio for prediction of establishing difference between sweet corn lots was checked o 19 separate triangle tests. All the actua values of correct judgements fell withi the 95 per cent confidence limits of th predicted results.

The ability for detecting difference between lots of sweet corn did not var among the judges. It was also found tha three triangle tests at one sitting was no fatiguing.

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# EFFICIENCY OF MARKETING EGGS IN DES MOINES[1]

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Consumer preferences for eggs and their reflection to sellers were investigated in this study as a means to estimating the efficiency with which eggs were marketed in Des Moines. An efficient egg market is defined as one in which consumers, under a given income distribution, obtain the greatest amount of satisfaction possible in the consumption of eggs so that no other method of marketing a given quantity of eggs will provide greater satisfaction. If preferences for eggs are not reflected to sellers, consumer satisfaction can be maximized only by chance

1 a. Chairman of Committee, Geoffrey Shepherd, Dept. of Economics and Sociology.
 b. Doctoral Thesis No. 1357. Submitted March 2, 1953.
2 a. B.S. University of New Hampshire, Durham, N. H., 1949.
 M.S. Iowa State College, Ames, Iowa, 1950.
 b. Research Fellow, Agricultural Experiment Station.

since sellers are unaware of desired qual ities. It is assumed that sellers can res pond to preferences, and that the onl reason they do not is because of imperfec knowledge of consumer preferences.

Consumer preferences for differer factors were examined. Interior qualit preferences were related to establish grades by obtaining observations fron respondents on four United States stan dards of quality for individual eggs, AA A, B, and C. Colored photographs o these grades were pasted on circular disk and randomly numbered. Top view photo graphs and top-view-with-profile photo graphs of these grades were used on tw different charts. The two charts gav similar results: There was no significan agreement on AA being preferred over A and vice versa, but AA (or A) was prefer red over B and B was preferred over C. The profile chart appeared to aid respon dents in their selection.

More general observations were ob tained on other preference factors. Res-

jndents were asked about shell cleanli-
ress, shell color preferences and yolk
color preferences. Shell cleanliness did
not appear to be a problem to respondents
though samples of store eggs did indicate
high number of dirty shells when graded
according to United States Department of
Agriculture standards. About 50 per cent
preferred a particular shell color; a
slightly larger number preferred white
an preferred brown shells. Darker yolk
colors were preferred to lighter yolk
colors.

Although it would have been informative
to learn whether or not respondents would
vy for their preferences, it was conclu-
ed that survey data would not permit such
estimates since the supply of varying qua-
ties and different preference factors
confounds any estimates of the relation of
ality and price. To take the supply fac-
r into account, it was concluded that
experimental designs in stores, in which
price differentials among qualities are
the stimuli, would provide estimates of
the monetary value consumers place on
references. Suggested experimental de-
signs were presented for studying prefer-
ances of one factor or several factors si-
multaneously.

The remainder of the analysis was in-
volved with estimating marketing effici-
ency and the extent that the utility func-
tion of consumers was maximized. The
following observations led to the conclu-
sion that the efficiency of marketing eggs
was not at a maximum:

(1) Higher quality and prices which ave-
raged ten cents lower at the farm appeared
to be primary reasons that 34 per cent of
the respondents purchased eggs from pro-
ducers.

(2) Eggs were not purchased at the near-
est sources by respondents because of dis-
trust of retailers, too high prices, and
poor quality.

(3) Of respondents buying eggs from re-
tail stores and primary producers, a much
higher per cent of store purchases were
unsatisfactory.

(4) Uncertainty of purchases was re-
peatedly referred to by respondents.

In view of the condition of quality un-
certainty in Des Moines, it was concluded
that marketing efficiency could be in-
creased, if not maximized, by introducing
a grading law in which the contents of a
carton of eggs were defined clearly to
buyers. Theoretical reasoning also led
to the belief that such a grading law would
minimize quality discounting and streng-
then, if not increase, the demand for eggs.

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# ESTIMATION OF THE GENETIC INFLUENCE ON GROWTH AND ORGAN WEIGHT CHANGES IN MICE FOLLOWING TOTAL BODY X-IRRADIATION[1]

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Department of Genetics

In order to estimate quantitatively the
influence of the genetic constitution on
radiation response, six genetically dif-
ferentiated inbred strains of mice, main-
tained at the Genetics Laboratory, Iowa
State College, have been exposed to total
body x-irradiation. The dosages were 0,
20, 200, 400, and 800 roentgens. The
age of exposure was 40 +3 days for all

mice. Equivalent numbers of each sex
and strain were placed at each exposure
level, permitting complete orthogonality
of comparison.

Body weights were determined at the
ages of 40, 41, 42, 45, 50, 55, and 60
days. At 60 days of age, the mice were
dissected, and the heart, kidneys, liver,
spleen, and testes were removed and
weighed.

The radiation factors were: 98 pKV,
2 ma., 36.5 centimeters target to mouse,
and a dose rate of 22.5 roentgens per 30
seconds. The filtration was that inher-
ent in the glass wall of the Coolidge-type
air-cooled tungsten target x-ray tube.

Strain or genetic differences in body
weight response to irradiation exist at
all age levels in this 20-day period.
They are maximum on the fifty-fifth day
of age, when they account for 17 per cent
of the total variation. The average res-

ponse of all strains is maximum between the second and fifth post-irradiation days, accounting for 43 per cent of the total variation.

An empirical method for scaling these six strains for their relative resistance to radiation has been outlined. As a high correlation exists between the weight change from initial weight and dosage, the regressions involved in this relationship form the basis of the scalding procedure. The regressions take into account the strain differences in normal rate of gain, and the rate and time of weight loss and recovery. These response factors are considered the most important in the expression of genetic response differences. The estimated positions of the strains are; RI: 68.1 per cent; Z: 64.8 per cent; S: 64.1 per cent; E: 52.7 per cent; L: 42.5 per cent; Ba: 0 per cent.

It is pointed out that the pre-irradiation body weight is an important variable that must be accounted for when quantitating the radiation response. In addition, evidence is presented to indicate that, on the average, the heavier strains and heavier mice within the strains are more resistant to weight change.

The female is concluded to be slightly more resistant than the male, but this variable in weight response is not an important one.

The observed body weight response has been postulated to be the result of several known gastro-intestinal, endocrine, and specific cellular disturbances that follow irradiation. It is assumed that genetic differences in weight response

may, equally, find their basis in genetic differences in the expression of these physiological alterations.

The heart, kidneys, and liver are found to be generally resistant to weight change. Significant increases in heart and liver weight occur in strains RI and L. The liver weight response has no immediate explanation.

At 20r, the spleen weight increases in all strains except strain E, wherein a decrease occurs. The average increase is significant and is postulated to be a defensive response to the low grade destructive effects of the radiation. Moderate changes in weight, at 200r and 400r, vary from strain to strain with heavier spleens being favored in the resistant strains. A large increase in weight at 800r is similar in all strains.

The testes weights decrease exponentially with increasing dosage. All strains respond in a parallel manner. The testes losses are assumed to be due to the direct effects of irradiation that cause a destruction of germinal elements.

On the basis of the over-all findings in the investigation, it is postulated that all strains are reacting in a similar manner to the direct effects of the radiation. Strain differences are considered to be expressed by an alteration of the secondary or indirect effects. Genetic variation in response is assumed to be based upon intrinsic capacities to resist the detrimental indirect effects and to enter more rapidly an effective phase of cell regeneration and/or recovery of normal metabolic levels.

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## EMBRYOLOGY OF INTERSPECIFIC CROSSES IN MELILOTUS[1]

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The plant breeder frequently finds that the range of variation within a species does not encompass the desired characters or qualities. Interspecific, or intergeneric, hybridization provides a possible method of introducing the desired genes into the species. Twelve species of Melilotus

were intercrossed and the embryology of the hybrids was studied. The species involved in this study are M. alba, M. officinalis, M. suaveolens, M. polonica, M. dentata, M. altissima, M. hirsutus, M. taurica, M. messanensis, M. italica, M. sulcata and M. speciosa. Among partially compatible crosses, M. officinalis x M. alba produces the most advanced embryo. Growth of the embryo proceeds normally until about eight days, and more slowly thereafter until the 12th or 13th day, when growth is completely inhibited and the embryo aborts. The reciprocal M. alba x M. officinalis embryo does not grow as

e or differentiate as much before abort-
by the 11th day. Other crosses, includ-
M. officinalis x M. suaveolens and M.
x M. messanensis, form a normal
embryo that grows slowly to about the
h day. The proembryo then loses po-
ty, organ development becomes abnor-
l, and the ovule aborts about the 12th
. Aborted embryos are also produced
the cross, M. alba x M. dentata. Re-
rocal crosses of M. suaveolens and M.
ssima and M. altissima x M. polonica
duce essentially normal embryos up to
ht days. These crosses may be sources
economically important germ plasm.
osses of M. altissima x M. alba and
italica x M. altissima exhibit embryo
ortion. The suspensor becomes necrotic
four or five days, and the proembryo
ats into the ovule cavity which contains
ndant non-cellular endosperm. In the
oss, M. officinalis x M. altissima, nei-

ther zygote nor the primary endosperm
nucleus divides. When M. altissima is
used as the female parent, the zygote does
not divide but the endosperm proliferates.
In the cross, M. italica x M. officinalis,
neither the zygote nor the endosperm di-
vides. Embryos of M. italica x M. sulcata
grow for four or five days, but the primary
endosperm nucleus does not divide. The
hybrid seed of M. alba x M. suaveolens is
54 per cent by weight of the seed of either
parent. Although developing ovules are
smaller than those of M. suaveolens x M.
alba, the embryo of the former is much
larger and more differentiated, and endo-
sperm is more abundant. This relation-
ship between these two compatible species
is of particular theoretical interest. Al-
though many of the crosses do not mature
viable seed, some embryos develop nor-
mally to a point where they would be wor-
thy subjects for culture on nutrient agar.

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# CERTAIN RESPONSES OF DOMESTICATED BIRDS TO INFECTION WITH PLASMODIUM LOPHURAE COGGESHALL, 1938[1]

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### Department of Zoology and Entomology

The investigations in this research were
undertaken to determine some of the res-
ponses which domesticated birds make to
the malarial parasite, Plasmodium lophu-
ae. Observations were made of the fol-
lowing: (1) degree of parasitemia exhibi-
d; (2) responses of infected birds to dif-
ferent diets; (3) daily variations in body
temperature readings; (4) weight changes
during parasitemia; (5) appearance of eye-
d lesions; (6) phagocytic activity in vari-
us host tissues; (7) appearance of mala-
ial pigment in the different organs; and
) phanerozoite stages of the malarial
arasite. Emphasis was on Nos. 6 and 8.

The 88 chicks used in the research com-
rised 10 different groups which varied in
umber from three to 15. Each group was
iven the regular starting ration for at
east two days before being placed on a
pecial ration. Two groups were given
egular rations throughout the investiga-

tions. The others were placed on rations
designated, respectively, G, Q, R and S.

The ten ducks and two turkeys were gi-
ven regular rations at all times.

1. The dosage of $0.8 \times 10^8$ parasitized
red blood cells from a duck per 100 grams
of body weight of chick, injected intrave-
nously, produced different levels of para-
sitemia in the individual chicks. This was
observed even for chicks of the same ser-
ies whose weights were the same on the
day of inoculation. The highest peak para-
sitemia attained was 100 per cent for chick
No. 1686 of the 3 A series on the fifth day
following inoculation. Another chick of the
3 A series, No. 1681, weighed the same
as chick No. 1686 (93 grams) on the day
they were inoculated, and reached the peak
parasitemia on the fifth day, but in this
case the peak was only 35.85 per cent.
The lowest peak parasitemia observed was
12.75 per cent for chick No. 12 of the 5 B
series.

A dosage of 0.9 cc of an emulsion made
from turkey brain infected with phanero-
zoite stages of P. lophurae, and diluted
1:20 with normal saline, produced demon-
strable blood stages of the malarial para-
sites in seven of the ten ducks inoculated.
Apparently this dosage was not sufficient
to produce severe parasitemia in any of

bɪds. Although 524 organs from 62 birds, including 50 chicks, 10 ducks and two turkeys were carefully observed with an oil immersion lens, phanerozoite stages were observed on only one turkey. These were found in the brain capillaries of a smear stained with Giemsa. Apparently this turkey died when the phanerozoite number was at its peak in the capillaries. They were not observed in any other organ than the brain.

In two brain smears of one of the ducks, four rather irregularly shaped, multinu-

cleated, blue-staining bodies were observed. They measured from 41.4 to 46.4 microns in length, with the widest diameters from 14.0 to 22.2 microns. Their appearance did not conform to the classical descriptions of any phanerozoites thus far described, so further investigations should be made before a decision is made as to the true nature of these bodies. They may be pure artefacts, or they may be phanerozoites developing aberrantly in an unfavorable host.

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# BARLEY SCAB[1]

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Isolations from barley grain, grown in Iowa in 1951 and 1952, revealed that barley scab caused by Gibberella zeae (Schw.) Petch is a major problem in the production of barley in this region. Nine samples of barley seed showed an average of five percent G. zeae infected kernels. The amount of G. zeae varied from one in some samples to as high as 11 percent. In addition to G. zeae, Helminthosporium sativum P. K. B. and Alternaria spp. were isolated most commonly from barley seed. The occurrence of many saprophytic fungi was also recorded. Several lots of Moore barley were heavily infected with the net blotch organism, Helminthosporium teres Sacc.

Cultural studies indicated that G. zeae is favored by warm temperatures. The optimum temperature for vegetative growth and conidia production was between 25° and 30°C. The optimum temperature for spore germination was approximately 30°.

Eight isolates of G. zeae showed some variation in their ability to parasitize barley spikes and seedlings. One isolate was highly pathogenic, six were moderately pathogenic and one isolate was weakly pathogenic.

Greenhouse studies revealed that spring

barley is susceptible to G. zeae from the boot stage until maturity. Hypodermic inoculations into the boot resulted in infections in those spikelets punctured by the needle. Plants inoculated in the flowering, past flowering, milk, soft dough and mature stages were all susceptible to G. zeae. The critical stage of development for scab infection appeared to be from the flowering period through the milk stage. In general, 72 hours incubation time gave a higher incidence of scab than the 48 or 60 hour series. Plants held at 24°C. after inoculation gave a higher percentage of infection than those incubated at 19°C.

The infection of barley spikelets through the dehisced anthers was commonly observed. Anthers which were partially extruded or completely dehisced and caught in the spike were visibly infected by the scab pathogen. The entrance of the fungus through the anthers appeared to be one of the primary means of initial infection.

A collection of 628 spring barley introductions and 30 named varieties were tested for scab resistance at Ames and Kanawha, Iowa, in 1951 and 1952. The plants were inoculated with G. zeae at Kanawha in 1951; the 1951 Ames nursery and 1952 Ames and Kanawha nurseries were not inoculated. In addition to moderate to heavy occurrences of G. zeae headblight, there was considerable blight caused by H. sativum. On the basis of percentage of blighted heads, 15 introductions were classed as possessing some resistance to G. zeae and H. sativum headblight. These introductions were primarily of the Manchuria six-rowed type. The percentages of blighted seeds caused by

a. Chairman of Committee, C. S. Reddy, Dept. of Botany and Plant Pathology.
b. Doctoral Thesis No. 1335. Submitted August 22, 1952.

a. B.S. Kansas State College of Agriculture and Applied Science, Manhattan, Kansas, 1948.
M.S. Iowa State College, Ames, Iowa, 1950.
b. Associate, Agricultural Experiment Station.

G. zeae and H. sativum were determined from plating tests of seeds from the 1951 Ames and Kanawha nurseries. Of the 628 introductions, 125 had five per cent or less G. zeae infected seeds. Of this group, 75 introductions also had five per cent or less H. sativum infected seeds. There were 368 introductions with five per cent or less H. sativum seeds. The most promising introductions were: C. I. Numbers 1113, 2551, 3197, 3512, 4195-2, 4427-1, 4445, 4445-1, 4458, 4795, 4820, 4825, 4883, and 4893.

The thirty named varieties were all sus-

ceptible to G. zeae and H. sativum head-blight to varying degrees. Chevron, C.I 1111 and Peatland, C.I. 5267, showed the lowest incidence of blight in 1951 and 1952. Three selections which include Chevron in their parentage were intermediate in their reaction to the headbligh organisms. The other named varieties many of which are grown commercially in Iowa, were very susceptible. There ap peared to be no correlation between date of heading and the percentage of head and seed blight in the barley introductions and named varieties.

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## ABSORPTION AND DIFFERENTIAL TOXICITY OF 2,4-D COMPOUNDS[1]

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Absorption of 2,4-D compounds was studied by spraying soybean and corn plants or dipping them into solutions of 2, 4-D and then washing the plants in a series of detergent and rinsing solutions after varying exposure intervals. Reductions in the new growth two weeks after treatment were considered as being directly proportional to the chemical absorbed.

Tests with soybeans and corn indicated that absorption was positively correlated with the length of the exposure interval. The ester form of 2,4-D was absorbed within a few minutes after treatment; the sodium salt entered the tissues slowly, and required hours for effective absorption, while the amine was intermediate in rate. The addition of surface active agents to the spray solutions increased the rate of absorption of all the 2,4-D compounds, but decreased the differential penetration rates.

The effect of the leaf carbohydrate supply on absorption of 2,4-D was studied by dipping soybean plants, previously held in darkness, into 2,4-D solutions, and then washing the 2,4-D residues from the plants after specified intervals. Leaf carbohydrates were not a critical factor influencing the absorption rates of 2,4-D.

Concentrations of sodium 2,4-D ranging from 1,000 to 10,000 ppm. were used t evaluate the effect of this factor on absorption by beans and corn. The rate of effective penetration was more rapid as the concentration, and consequently the quantity of 2,4-D applied was increased.

To investigate the effects of temperature on absorption, soybean plants were exposed to different temperatures 2 hours before and 30 minutes after dipping in 2, 4-D solutions. The data indicated that the over-all $Q_{10}$'s for the absorption process were approximately 2, showing that a chemical or physiological reaction limits absorption.

To test the effect of soil moisture on the penetration of 2,4-D, soybean plants were grown with soil moisture held near the field percentage, and others were watered only after the plants had nearly reached the permanent wilting point. More rapid penetration occurred where the plants had been supplied with adequate water and were less differentiated.

Several experiments were performed to evaluate the effect of pH on absorption of 2,4-D compounds. Buffered solutions of 2,4-D at pH's of 5, 7, and 9 were used on soybeans. The sodium and amine forms were less toxic at pH 9 than at 5 or 7.

Absorption differences between the monoethylamine and dioctylamine salts of 2, 4-D on soybeans were determined. The monoethylamine form penetrated more rapidly than the dioctylamine during 30 and 60 minute exposures. This result is in agreement with the molecular size or sieve theory.

# OVERCOMING OBSTACLES TO SOIL EROSION CONTROL IN WESTERN IOWA[1]

ROYER BURNELL HELD[2]
Department of Agricultural Economics

Erosion continues to be a serious prob-
m on farms in the Ida-Monona soil area
western Iowa even with the aid given
rmers by public programs to reduce
il losses. Investigating this problem in
'49, Frey found that four major obstacles
opeared to be preventing farm operators
om achieving lower soil losses (1).
hese were the changes required in farm
iterprises, rental difficulties and lack
the landlord's cooperation, financial
bligations and living costs, and expecta-
ons of short tenure. The objectives of
zis study were to determine what effect
nanges in these obstacles would have up-
n soil losses, to determine the factors
hich create obstacle situations, and to
etermine how obstacle situations might
e overcome.

Data were obtained during 1952 by inter-
iewing operators and landlords on the 144
arms which Frey had studied, giving par-
icular attention to changes which had oc-
urred since then which might have elim-
nated or lessened a previous obstacle, or
night have brought about a new obstacle,
r made an existing obstacle worse. Soil
osses were calculated on each farm for
952 and compared with the loss rate in
949.

The same socio-economic conditions
which appeared to be obstacles in 1949

were observed again in 1952. While some
changes were observed in all obstacle sit-
uations, the greatest improvements came
about where the financial situation and
where the organization of farm enterprises
had been obstacles. There was little dif-
ference in the rate of change in soil loss,
however, between the farms on which ob-
stacles had made no change, the farms on
which they had been overcome, and the
farms on which the obstacle was more of
a problem than before.

Soil losses for the entire sample were
approximately the same as they had been
in 1949. Soil losses had decreased on
some farms but had increased on other
farms with the result that the mean change
was a reduction of only 1.5 tons per acre.
If operators had put into practice those
measures which they indicated were needed
in 1949, the reduction in loss might have
averaged 5 tons per acre. If they had suc-
ceeded in reducing losses to a point con-
sistent with the public interest, the reduc-
tion would have averaged 15 tons per acre.

Variations in soil loss changes were
greatest where a change in operators had
occurred. Attitudes, circumstances of
tenure and economic conditions for the
new operator were sufficiently different
from those of the previous operator to
cause important changes in soil loss.

Noteworthy changes in the rate of soil
loss occurred on 47 per cent of the farms
sampled. Of these, 59 per cent had re-
duced soil losses by more than 5 tons
while on the remainder of these farms soil
losses had increased by more than 5 tons.
Considering only these two groups of
farms, where the operator's share of the
marginal costs of an input related to ero-
sion control had changed so it was not the

same as his share of the marginal returns, the rate of soil loss tended to increase. Similarly, where changes had occurred which more nearly equated the portion of those costs and benefits which were borne by the farm operator, erosion losses tended to decrease. Where the pressure of debt had increased, losses tended to increase. Where operators had become more aware of the effect of losses from erosion on yields, losses tended to decrease.

A need for increased educational work exists. Farmers were not making use of means already available which might be used to overcome obstacle situations. This is due in part because they are not familiar with the techniques which might be used or they have been misinformed concerning them and, in part, because custom or habit prevent the use of them. The use of leases which will permit the optimum use and combination of resources in the firm, both during a particular production period and for a series of such periods, will depend largely upon the success of educational efforts, for the initiative to make these changes must be taken by the owners and the operators.

Off-site damages or off-site benefits which are not reflected as costs or revenues to the firm require action beyond that which the individual can take. Satisfactory adjustments are possible through group action. One of the most promising developments of this type is that of the conservancy district which makes it poss ible to tax those who receive benefits t compensate those who must make the in vestments which yield the off-site benefits

Beyond the point of private or grou profitability, public efforts will be re quired if erosion losses are to be reduce further. Where costs and benefits ca not be associated because of their disper sion, and a change in the use of land is i the public interest, there is a need fc public grants, subsidized credit and pub lic investment. A partial alternative migh! be action to assure a greater degree o certainty in market conditions which, a present, make cattle enterprises hazarc ous for persons of limited capital.

Changes in legal concepts with respect to damages caused by the flow of water from higher to lower ground deserve consideration in light of what can now be don to control runoff water. Public ownership and the police power stand as the ultimate tools society may use to bring about land use which conforms with the goal of society. These methods, however, should be reserved for the problems of greatest urgency where other techniques are not effective.

### REFERENCE

1. Frey, John C. Some obstacles to soil erosion control in western Iowa. Iowa Agr. Exp. Sta. Bull. 391. 1952 p. 945.

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## INTENSITIES IN THE HOLLOW CATHODE DISCHARGE[1]

### JOHN P. HELLER[2]
Department of Physics

In addition to the arc and spark as light sources for spectroscopy, electrical discharges through low pressure gases have proved quite useful in the excitation of spectra of many materials. In particular, when the cathode is of a hollow shape, the concentration of the glow within it, and the consequent alteration of the discharge processes contribute special features of value to the spectroscopist. These features include high brightness level, strong excitation of atoms introduced into the dis-

charge by cathode sputtering, and very low electric field throughout the plasma. In addition, if the cathode may be cooled, doppler widths of the spectral lines may be reduced substantially. For these reasons, the tube has been used very effectively for high resolution spectroscopy.

In this research, a hollow cathode tube was built in accordance with the special requirements of such application. The actual cathodes were interchangeable and of various internal diameters. The cathode material was aluminum, and the tube was operated with helium as a carrier gas. The latter was continuously circulated through the discharge and through appropriate purification traps. Following recent practice in the field, the circulation

s arranged to provide a "gas window"
er the open end of the cathode to reduce
t: loss of sputtered material from the
.scharge.

:The spectrum of singly ionized alumi-
m emitted from the cathode was exam-
:d with the aid of a quartz spectrograph,
d observations of the source brightness
selected wavelengths were made. The
:riations in brightness due to changes in
:rrier gas pressure, cathode size and
,mperature, and discharge current were
udied. These external parameters were
.ried over the range customarily practic-
·le with this type of discharge tube. The
·scharge was photographed using five
.thodes from 3.50 to 17.7 mm bore, at
:ree temperatures from -190° C. to 100°
., with high and low currents and with
:lium pressures from 1.0 to 6.0 mm of
g.

The brightness measurements were
.ade by comparison with the known ther-
.al radiation from a tungsten ribbon-fila-
.ent in a special quartz and glass incan-
.escent lamp bulb. Both the comparison
:ource and the hollow cathode tube were
:hotographed in the wavelength range from
:490 to 6200 Angstroms, and the blacken-
:ng of the photographic plates compared
.hotometrically. Brightnesses of the vari-
:us aluminum lines were then calculated
:n a scale which was arbitrary in absolute
:magnitude but uniform throughout the above
:wavelength region.

The aluminum lines selected for meas-
.urement included three from low-lying Al II

levels and all detectable members of three
line series from more highly excited lev-
els. The results of these measurements
showed that the overall excitation of alu-
minum to ionized states was strongly de-
pendent on carrier gas pressure and on
current. Average line brightness varied
approximately as the square of the wall
current density to the cathode, and in-
creased to a maximum near the lowest
pressure at which it was possible to main-
tain the discharge. The cathode size af-
fected the position of this optimum pres-
sure, and the brightnesses were also found
to be somewhat greater at higher tempera-
tures.

The brightnesses of the series lines con-
formed roughly with the above behaviour,
but in addition showed definite non-unifor-
mities in the excitation processes. These
were evidenced by much higher bright-
nesses of some of these lines than their
series neighbors, under conditions of high
current and small cathode size.

An attempt is made to interpret the var-
iations of brightness of the Al II lines in
terms of the atomic processes of sputter-
ing, excitation by electron bombardment
and collisions of the second kind with he-
lium metastables, and diffusion and re-
combination of ions. In addition, several
possible collisions of the second kind with
other excited helium states are suggested
as possible processes leading to the non-
uniform excitation of the higher series
members.

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## ANGULAR DISTRIBUTION OF PHOTOPROTONS FROM ALUMINUM AND TANTALUM[1]

MARVIN M. HOFFMAN[2]
Department of Physics

Information concerning photonuclear
transformations may be obtained from the
study of the particles which are emitted
from nuclei when irradiated with photons.
In order to add to the available informa-
tion on the emitted protons, aluminum
and tantalum have been exposed to the
bremsstrahlung radiation of the Iowa State
College synchrotron and the tracks of

emitted particles have been recorded in
photographic emulsions. For this inves-
tigation 1 x 3 inch Ilford C-2 500 μ nuclear
emulsions were exposed in an evacuated
camera provided with a thin window in
each end through which the beam passed.
Collimation was obtained with two circu-
lar apertures in succession which gave a
beam approximately 1 cm in diameter at
the camera.

The emulsions were processed by a low
temperature method using an amidol dev-
eloper. Scanning was done with a 21X
objective lens and 15X eye pieces. Each
observed track was checked against four
selection criteria and for those which
were satisfactory, the position, depth and

length were recorded. The emulsions were exposed at $25°$, $60°$, $90°$, $120°$, and $155°$ to the direction of the collimated X-ray beam and with maximum X-ray energies of 25, 40, and 65 Mev for aluminum and 25, 38, and 65 Mev for tantalum.

The track density in each plate was corrected for relative geometry and used as an indication of the relative number of protons emitted at that angle. In the case of tantalum the angular distribution thus obtained has been plotted and compared to the function $I = A + B \sin^2 \theta$. Using the best fit of this function to the experimental points, $B/A = 1.7$ for protons from 0 to 19 Mev, $B/A = 8$ for protons from 18.6 to 28 Mev, and $B/A = \infty$ for protons from 27 to 40 Mev. For aluminum the function $I = (\sin \theta + p \sin \theta \cos \theta)^2$ plus a constant portion was fitted to the experimental points. The constant portion comprised the entire group for the 25 Mev exposure while for the 40 Mev exposure $p = 0.7 + 0.1$ and for the 65 Mev exposure $p = 0.6 + 0.2$.

From the known range-energy relation for protons in emulsion the energy distribution of emitted protons has been determined. These experimental points have been plotted and in the case of low energy protons where no intervening absorber was used, the distribution predicted by the statistical theory of photonuclear reactions has been superimposed. For aluminum the theoretical curve fits

the experimental points quite well wh normalized to enclose the same are Since the fit was not good for tantalum, t theoretical curve has been plotted twic In one case it has been normalized to e close the same area as the experiment points while in the other it has been no malized so that the leading edge approx mately fits the experimental points. F higher energy protons observed behind a sorbers the relative number of observ protons has been plotted against the co rected proton energy. The observed num ber of protons was found to decrease wi increasing proton energy as $E^{-6.5}$ for pr tons from 19 to 28 Mev, as $E^{-7.5}$ for pr tons from 27 to 40 Mev from tantalum and as $E^{-6}$ for protons from 16 to 28. Mev, as $E^{-7}$ for protons from 27 to 43 Me from aluminum.

From the calculated geometry in whic the emulsions were exposed and the ob served track density the following yiel points were determined. The value o ($p/\text{mole Al}$) to ($n/\text{mole Cu}^{63}$) for aluminun was found to be $0.30 + 0.02$ for irradia tion at 25 Mev, $0.034 + 0.002$ for irradia tion at 40 Mev and $0.0084 + 0.0010$ for ir radiation at 65 Mev. For tantalum the value of ($p/\text{mole Ta}$) to ($n/\text{mole Cu}^{63}$) was found to be $0.062 + 0.006$ for irradiation at 25 Mev, $0.0062 + 0.0005$ for irradiation at 38 Mev and $0.0045 + 0.0004$ for ir radiation at 65 Mev.

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## RATIO METHOD OF ESTIMATION IN SAMPLE SURVEYS[1]

### DANIEL G. HORVITZ[2]
Department of Statistics

The ratio method of estimation in sample surveys involves the use of estimators for population parameters which are linear functions of the ratio of dependent random variables. Only large sample approximations for the bias and sampling variance are available for measuring the accuracy of ratio estimators. This study is concerned with three aspects of the properties of ratio estimators as they are used in sample surveys.

First, using a theorem of Cramér, re-

garding the asymptotic distribution of functions of sample moments for random samples from joint continuous distributions $f(x, y)$ having finite first and second moments, it was found that the ratio of the sample means was asymptotically normally distributed with mean equal to the ratio of the true means and variance given by usual approximate formula. It is noted that the argument of Fisher for obtaining interval statements about the true quantity can be used, if the $t$ distribution can be assumed to hold for samples from finite populations. This assumption is probably fairly realistic.

Second, exact expression for the bias and variance of ratio estimators have been obtained under various assumptions regarding the joint distribution of the variables sampled. In particular, these as-

su ptions restricted the types of regres-
sir and conditional variance relationships
e bited by f(x, y). For the variance laws
c idered and the true mean square re-
g sion of y on x linear, it was found that
e ct expressions for the bias and variance
o atio estimators depend on the existence
o he first and second moments of the dis-
ti ution of the reciprocal of the sample
n in of the denominator variable. The
u al approximate formula for the variance
v then compared with the exact expres-
s ns when f(x) followed the Pearson Type
I and the truncated binomial distribution.
I these distributions and whenever the
r gression and variance relationships con-
c ered prevail, the sample size required
t achieve reasonable accuracy with the
r roximate variance formula depends on

the magnitude of the coefficient of varia-
tion of the denominator variable of the
ratio estimator. The larger this coeffi-
cient, the slower is the convergence of the
approximation to the exact variance ex-
pression.

Third, a systematic comparison of the
ratio estimator with other possible me-
thods of estimation using the information
available on a supplementary variable was
conducted. The comparison was restricted
to situations in which specific conditions
on the form of the regression and on the
residual variance law were satisfied by
the joint distribution of the variables in-
volved. The ratio method of estimation,
as a general method of estimation, was
found to compare favorably.

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# ELASTIC STABILITY OF THE TOP CHORD OF A THREE-SPAN CONTINUOUS PONY TRUSS BRIDGE[1]

## CORNIE LEONARD HULSBOS[2]
Department of Civil Engineering

The object of this investigation was to
make an analytical study of the elastic
stability of the top chord of a three-span
continuous pony truss bridge.

The pony truss bridge that was used as
an example was designed by the Iowa High-
way Commission in 1947 and erected over
the North River on State Highway 60 a few
miles southeast of Des Moines, Iowa. The
bridge has twenty 15-foot panels with a
center span of 150 feet and end spans of
15 feet. For the stability analysis the top
chord and end post members were consid-
ered as an elastically supported beam-
column member. The beam-column mem-
ber was considered hinged and fixed against
lateral deflection at the ends of the span
and elastically supported against lateral
deflection at the intermediate panel points.
The elastic supports were provided by the
cross frames composed of the verticals of
the trusses and the floor beams framing
into the verticals. The entire effect of
the diagonal web members and the torsional
stiffness of the vertical members were

neglected. Also, it was assumed that the
top chord members were not deflected out
of a straight line, when viewed from above,
by the loads applied to the floor system.

Two criteria, series and stiffness, were
presented and were used as a basis for
checking the elastic stability of the top
chord members.

The series in the series criterion pro-
cedure is obtained from a moment dis-
tribution type of solution. Equations were
derived for the necessary constants re-
quired for a moment distribution solution
of a beam-column elastically supported
against deflection at intermediate points.
When the moment distribution series con-
verges a condition of stability is indicated,
but when the series diverges a condition
of instability is indicated.

Equations were derived for use in apply-
ing the stiffness criterion to obtain the ro-
tational and translational stiffnesses of
one end of a member considering the en-
tire structure beyond its far end. The
equations, as derived, for the stiffnesses
for the end of a member can be used to
determine the rotational stiffness of the
hinged end of a beam-column and can be
used to determine the rotational and trans-
lational stiffnesses of a joint provided that
the structure and stress conditions are
exactly the same on both sides of the joint.
The principles of the stiffness criterion
are:

a. Chairman of Committee, Frank Kerekes,
   Dept. of Civil Engineering.
b. Doctoral Thesis No. 1407. Submitted
   June 3, 1953.
a. B.S. Iowa State College, Ames, Iowa,
   1941.
   M.S. Ibid., 1949.
b. Assistant Professor, Dept. of Civil
   Engineering.

1. When an external clockwise moment, under a condition of equilibrium, is required at a joint to rotate the joint in a clockwise direction, there is an indication of stability; but, when the external moment necessary to hold the joint in equilibrium is opposite to the direction of rotation, then there is an indication of instability.

2. When a lateral force, under a condition of equilibrium, is applied at a joint and when the direction of the deflection of the joint is in the direction of the applied force there is an indication of stability; but, when under a condition of equilibrium, the direction of the force must be opposite to the direction of the deflection of the joint, then a condition of instability is indicated.

The process of determining the load factor that produces a stress condition which causes buckling must be one of trial; that is, the structure must be analyzed for stability with various load factors until a condition of instability is found or until the stresses reach the yield stress. In applying the series and stiffness criteria, the buckling curve corresponding to the minimum load factor must be obtained. If the beam-column buckles with a node at one of the joints, the value of the translational stiffness of that joint may indicate a condition of stability; and, if the beam-column buckles with a point of maximum deflection at one of the joints, the rotational stiffness of that joint may indicate a condition of stability, and the stability factor determined with the use of the series criterion may indicate a condition of stability. Therefore, any results obtained by the use of the series and stiffness criteria must be carefully interpreted.

Of the two criteria, series and stiffness, the stiffness criterion involves a smaller number of equations and when it can be used it is the more practical of the two procedures. The series criterion can be applied to any joint and therefore can be considered as the more general procedure

of the two. However, only the rotation stiffness of a joint can be checked by th series criterion procedure.

In checking the top chord of the three span continuous pony truss bridge, th series and stiffness criteria must be ap plied to one of the joints in the region compressive stress. The regions of ter sile stress adjoining the regions of com pressive stress have a stiffening effect o the members in compression and have tendency to reduce the possibility of buck ling.

The stresses in the top chord member were computed for two live loading condi tions. The top chord was checked for sta bility for these two stress situations in th following manner:

1. For the loading condition that pro duced a maximum compressive stress ir the end spans, the series criterion wa used by applying an external moment a the end joint, and the stiffness criterio was used by determining the rotational stiffness of the end joint.

2. For the loading condition that pro duced a maximum compressive stress ir the center span, the stiffness criterior was used by determining the rotational anc translational stiffnesses of the joint at th center of the span.

A procedure was presented to determine the elastic constants for the inclined enc post member in terms of the horizontal projection of the member. A similar pro cedure could be used to include the effec of the other diagonal web members in ar analysis for stability. If the effect of the diagonal web members were included, the resistance of the top chord members to buckling would be increased.

The top chord of the three-span continu ous pony truss was checked for stability for the two conditions of live loading anc the member was found to be stable witl stresses in the top chord member whicl were within the elastic strength of the ma terial.

# EXPERIMENTAL DETERMINATION AND MATHEMATICAL EVALUATION OF PHYSICAL CHARACTERISTICS OF BEEF PROCESSED AT HIGH RETORT TEMPERATURES[1]

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Departments of Mechanical Engineering and of Food Technology

An investigation of physical character- istics of beef (round) and their mathema- tal evaluation were undertaken with the prpose of safe modification of processing thes and temperatures used at present. e range of temperatures investigated (25-315°F.) included relatively high temp- atures; correspondingly short times re used as it was thought that in this gion of processing conditions a process uld be found resulting in safe and pala- ble product. Twenty-five locations in a 300 x 308 can were investigated cover- g for all practical purposes the whole n volume.

The study was divided into three major rts; investigation of thermal properties, vestigation of thermobacteriological aaracteristics, and investigation of other aysical changes occurring in beef during anning.

Time-temperature-space relationships xisting in the container were determined ad prediction equations of exponential arm were developed for the heating and ooling phases of the thermal process by aeans of regression analysis. The effects ere evaluated of processing variables on ae number of terms to be retained in the xpansion of theoretical heat conduction quation to approximate the thermal his- ory of the can during the initial phase of ooling. The series was found to converge to its limit for twelve to four terms as the ooling time $(t-t_1)$ progressed from 2-10 ninutes. The differences from the retort emperature at the end of heating $(g)$ af- ected the number of terms to be retained; ess terms were required for small $g$. From the investigation of this phase of the hermal process it was found that neither he theoretical relationship nor a mono- tonic function approximation of time-tem- perature relationship agreed well with the experimental data. The effect of residual heating at the beginning of the cooling phase

on the effective processing time has been evaluated by graphical means.

Temperature distribution patterns have been mapped for the heating phase of the thermal process and found in disagreement with theoretical expectations: the locations of greatest heating lag were displaced from the center to form a doughnut shaped vol- ume around the central vertical axis in the central horizontal plane. The isothermals displayed cardioid characteristics. These effects were found to be real and caused most likely by the anisotropy of meat and departure from uniform initial tempera- ture distribution in the can.

Thermal diffusivity of the round of beef has been determined $(k_{av} = 0.2623$ sq. cm./min.) and found to be affected by pro- cessing temperature. The "slopes" of heating $(f_h)$ and cooling $(f_{cl})$ curves were determined and compared. A comparison of visual and regression curve fitting me- thods and their effects on "slope" values was made.

Sterilizing effects $(F_o)$ of high tem- perature short-time processes displayed large variations and precluded derivation of prediction equations; therefore, $F_o$ dis- tributions have been presented in graphical and tabular form. A doughnut shaped vol- ume of lowest $F_o$ values was found to be a secondary effect of temperature distribu- tion and of residual heating. This pheno- menon as well as the contribution of the residual heating to $F_o$ values was found to be more pronounced at higher retort tem- peratures. Processing times equivalent in terms of $F_o$ at the center were deter- mined for six temperatures; considerably shorter times at high temperatures than at low ones were necessary to attain the same $F_o$ levels.

Objective determinations of tenderness were made. Approximate linear relation- ship of shear force and processing time and exponential relationship of the slopes of this function and processing tempera- ture were developed by regression tech- nique. Visual interpretation of these re- lationships was presented by means of a three-dimensional graph. The objective evaluation of juiciness was given in a lin- ear regression of drained juice on a time- temperature transform. Shear force data displayed considerable variation and did not lend themselves to a simple mathema-

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1 a. Chairmen of Committee, Henry M. Black, Dept. of Mechanical Engineering, and Robert Tischer, Dept. of Food Tech- nology.
  b. Doctoral Thesis No. 1420. Submitted June 8, 1953.
2 a. B.S. Iowa State College, Ames, Iowa, 1949.
  M.S. Ibid., 1950.
  b. Graduate Assistant, Agricultural Experiment Station.

tical interpretation. Shear force has been found to increase at the beginning of the process, pass through a maximum and then decrease approximately as a linear function of time. Drained juice data showed similar variations and this attribute was found to be a well behaved monotonic function of time.

A comparison was made of shear force and drained juice with sterilizing effects. The shear force for equivalent processes displayed a maximum between 261 and $279^\circ F$. retort temperature. For the same $F_o$ levels the quantity of drained juice increased from $243-315^\circ F$.

The precision of estimates of parameters and of prediction equations was evaluated wherever it was feasible.

The inherent variation in the shear force determinations by means of Warner-Bratzler Shear were discussed in an appendix. A new method of computation of thermal process lethality, similar to the "general method" procedure, has been developed to account for continuous exposure of bacteria to heat during processing. This method has been presented in an appendix.

The conclusions drawn on the basis of this investigation were as follows:

(1) The average time - temperature-space relationship in the can may be expressed for heating and cooling phases of thermal process by straight-line function in semi-log coordinates. No simple relationship can be derived for the initial period of the cooling phase.

(2) The residual heating during the initial period of cooling increases the effective processing time. This increase is more pronounced for high-temperature short-time process. The contribution of residual heating to the sterilizing effect shows the same trend and possibly reaches a maximum at $297^\circ F$. retort temperature.

(3) Thermal diffusivity of beef does not depend on the location in the container; it may be, however, a function of processing temperature and reaches a maximum for $261-279^\circ F$.

(4) The "slopes" of heating and cooling curves are significantly different and cannot be used interchangeably. Regression estimates only should be used for thermal process determinations.

(5) The temperature distributions displaying a doughnut shaped volume of lowest temperatures in the central horizontal section of the can are a real occurrence caused by anisotropy of beef and nonuniform initial temperature distribution as reflected by the analysis of intercept coefficients in the heating equation.

(6) The $F_o$ determination is subject to great experimental variations and, to assure a determination of a safe but not excessively long thermal process, the size of the experimental sample should be determined by statistical methods. The $F_o$ distribution (similar to temperature distribution) observed emphasizes the necessity of process determination based on volume lethality concept.

(7) Maximum shear force may be expressed approximately as linear function of time. The slope of this function may be expressed as an exponential function of the processing temperature.

(8) The drained juice accumulation may be expressed as a linear function of a time-temperature transform.

(9) Processing temperatures between $261-279^\circ F$. display characteristics of a critical range where most of the physical characteristics of beef assume their extrema. This temperature range may prove to be optimal for canning of safe and palatable beef.

# SOME DERIVATIVES OF DIBENZOFURAN AND DIBENZOTHIOPHENE[1]

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Department of Chemistry

The announcement by Barry (1) of the considerable antituberculous activity of 2 - chloro - 7 - aminodibenzofuran, the reported activity of derivatives of 4-halo-4'-aminodiphenyl ether, and the antituberculous activity of derivatives of 4,4'-diaminodiphenyl sulfone prompted the preparation of a series of dibenzofuran and dibenzothiophene compounds.

The treatment of 2-bromo-7-acetaminodibenzofuran with bromine gave a mono-bromination product melting at 235-236° (73 per cent). This compound was hydrolyzed to the amine (90 per cent, m.p. 182-183°). The amine was proved to be 2,8-dibromo-3-aminodibenzofuran by deamination to yield 2,8-dibromodibenzofuran.

An attempt to prepare the amino-dibromo derivative by a different sequence led to the bromination of 2-bromo-3-acetaminodibenzofuran, giving a dibromo-acetamino derivative melting at 233-236° (32 per cent). A mixed melting point with 2,8-dibromo-3-acetaminodibenzofuran was greatly depressed; the compound was thus thought to be 2,4-dibromo-3-acetaminodibenzofuran. Attempted mononitrations of 2,8-dibromodibenzofuran with nitric acid and acetic acid or acetic anhydride were unsuccessful. Nitration of the dibromo derivative with concentrated nitric and sulfuric acids gave a dinitro-dibromodibenzofuran melting at 332-335°.

Alkali fusion of 2-bromodibenzofuran or 2,8-dibromodibenzofuran when carried out in either diethylene glycol or triethylene glycol gave only reductive debromination (2).

2-Bromo-7-nitrodibenzothiophene-5-dioxide (52 per cent, m.p. 319-321°) was prepared by nitration of 2-bromodibenzothiophene-5-dioxide. Catalytic reduction of this compound gave 2-bromo-7-aminodibenzothiophene-5-dioxide (67 per cent, m.p. 331-333°).

The treatment of dibenzothiophene-5-oxide with bromine yielded 2,8-dibromodibenzothiophene (3). The reduction was attributed to the hydrogen bromide formed with initial bromination; this explanation was confirmed by the treatment of the 5-

monoxide with bromine-free hydrogen bromide, which yielded dibenzothiophene (33 per cent). Attempts to brominate dibenzothiophene-5-oxide with N-bromosuccinimide were unsuccessful.

3-Bromodibenzothiophene was prepared from 3-aminodibenzothiophene by the Sandmeyer reaction and from 3-bromodibenzothiophene-5-dioxide by reduction with lithium aluminum hydride. The 3-aminodibenzothiophene was prepared by nitration of dibenzothiophene-5-oxide and subsequent reduction of both the sulfoxide and nitro groupings.

The reaction of lithium with phenothiazine, 10-ethylphenothiazine and carbazole in dioxane was investigated. With phenothiazine, hydrolysis of the dioxane reaction mixture yielded o-mercaptodiphenylamine (29 per cent) and diphenylamine (4.4 per cent); essentially the same results were obtained on carbonation of the reaction mixture. With 1-ethylphenothiazine, carbonation of the reaction mixture gave o-mercaptodiphenylethylamine (33 per cent). With carbazole and lithium in dioxane only starting material was isolated (88 per cent recovery).

A series of heterocyclic sulfides was prepared by treatment of the sodium salt ot the mercaptan with the appropriate halogen compound (4). The following sulfides were synthesized: 2-(benzylmercapto)-quinoline (82 per cent, m.p. 44-44.5°), 2-(n-dodecylmercapto)-quinoline (70 per cent b.p. 185-188°/2 mm.), 2-n-hexadecylmercapto)-quinoline (62 per cent, m.p. 43-44°), 2-(n-octadecylmercapto)-quinoline (85 per cent, m.p. 53-54°), 2-benzothiazolyl 2-quinolyl sulfide (78 per cent, m.p. 109-111°), 2-(4-phenylthiazolyl) 2-quinolyl sulfide (50 per cent m.p. 88-91°), 2-benzimidazolyl 2-quinolyl sulfide (60 per cent m.p. 32.5-34°) and 4-(7-chloroquinolyl) 2-benzothiazolyl sulfide (44 per cent, m.p. 138-140°).

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## CONDUCTANCES AND TRANSFERENCE NUMBERS OF SOME RARE EARTH PERCHLORATES, SULFATES AND NITRATES IN AQUEOUS SOLUTION[1]

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The conductances and transference numbers of the perchlorate salts of lanthanum, praseodymium, neodymium, samarium, gadolinium, holmium, erbium and ytterbium were measured. The conductances and transference numbers of the nitrate salts of lanthanum, neodymium and gadolinium were also measured. In addition, the conductances of the sulfate salts of lanthanum, cerium, praseodymium, neodymium, samarium, gadolinium, holmium, erbium, ytterbium, and yttrium were determined. These were all measured in aqueous solutions at 25°C.

The Jones bridge and its accessories were employed to measure the conductances over a concentration range of about 0.0002 N to 0.1 N. The accuracy of the conductance measurements is estimated to be about 0.1 per cent which is the extent to which the concentrations of the solutions are known.

The perchlorate conductances appear to decrease with increasing atomic number except for lanthanum, praseodymium and neodymium. These three salts have very similar conductances. The behavior of the series is attributed to the effective increase in the size of the ions due to hydration, in spite of the fact that the ionic radii from crystallographic measurements are decreasing with atomic number. The three nitrates measured exhibit similar behavior to that of the perchlorates.

However, the conductances of the perchlorates as a whole are higher than those of the nitrates except at very low concentrations. This seems to indicate that the interaction of the perchlorate ions with the rare earths, at concentrations above about 0.01 N, is less than the corresponding inactions of the nitrates and the halides. This behavior would tend to increase the total conductance of the perchlorates as compared with the nitrates. The conductances of the nitrates and the halides are parallel from infinite dilution to 0.1 N; whereas, the conductances of the perchlorates cross those of the halides and nitrates,

and are higher than both of them above 0.1 N.

The conductances of the rare earth sulfates are much lower than expected for completely dissociated strong electrolytes. The low mobilities of the sulfates are attributed to the formation of complexes or ion pairs even in dilute solutions. The most prevalent complex at moderate dilutions is proposed to be $MSO_4^+$ in which M is the rare earth.

The series of rare earth sulfate conductances exhibit a far different order from that of the other salts measured. At appreciable concentrations the sulfate conductances decrease slightly from lanthanum to praseodymium and then rise a little at neodymium. They fall again to a minimum at samarium and finally increase steeply from samarium to ytterbium. Yttrium behaves much like the heavy rare earths in its conductance. This order in the sulfate conductances may be attributed to the relative stabilities of the rare earth complexes as the atomic number is increased.

The conductances of the rare earth sulfates are completely different at infinite dilution. They are completely dissociated at infinite dilution and they behave as do the other rare earth salts.

The ionic equivalent conductances at infinite dilution were calculated for these salts and the values are in good agreement with those previously calculated from the rare earth halide data.

The transference numbers of the rare earth perchlorates and nitrates were measured by the moving boundary method. The accuracy of the method is estimated to be about 0.1 per cent. However, it is conceivable that the errors in the measurement of time, volume and current could add up in such a way as to give an overall accuracy of only 0.2 per cent.

The order of the perchlorate transference numbers is in relative agreement with the rare earth halide transference numbers. Lanthanum is a little lower than expected but still quite close to the light rare earths. However, samarium appears to behave contrary to its conductance. The transference number is close to that for praseodymium while its conductance is much lower than that of praseodymium.

The ionic conductances of the rare earth perchlorates and nitrates were calculated

from the conductance data and the transference numbers. They provide a cross check with the conductances, since the ionic conductances of the anions fall on relatively the same curves.

The use of the Onsager equation for the extrapolation of the conductances to infinite dilution indicated that a further correction on the conductances would give much better agreement with theory. This agreement was obtained when the extended Onsager equation was used. The extended equation includes a dependence on the mean distance of closest approach in the electrophoretic effect correction. This led to a method for determining the distances of closest approach for the rare earth perchlorates and nitrates from conductance data. The $a_i$ values determined from the conductance data were quite reasonable

and were used to calculate activity coefficients. The activity coefficients appear to be satisfactory and compare favorably with those of the rare earth halides which were determined from e.m.f. measurements. Since the activity coefficients for the rare earth perchlorates and nitrates are not available from experimental measurements, the conductance method affords a convenient and reasonably accurate method of obtaining them.

The data on the transference numbers and conductances presented in this thesis should be of valuable importance in the study of equilibria and kinetics of rare earth salt solutions. It is hoped that these data will help point the way towards extentions in the present theories and provide a better understanding of the physical chemistry of electrolytic solutions.

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# EFFECTS OF ANTIBIOTIC AND LYSINE SUPPLEMENTATION ON GROWING-FATTENING PIGS FED AT DIFFERENT PROTEIN LEVELS[1]

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The purposes of these studies were to determine the optimum levels of protein in corn-soybean oil meal rations for growing-fattening pigs and to study the effects of antibiotic and lysine supplementation on different protein levels.

Data from 336 pigs, including purebred Duroc and Poland China x Landrace x Duroc pigs group-fed in drylot, showed that with nutritionally balanced rations optimum growth and feed efficiency were obtained on protein levels which were lower than those previously recommended. It was further shown that with the antibiotic aureomycin included in the rations at a level of 10 milligrams per pound, growth response was obtained which was equal to that realized from non-aureomycin rations containing two or more additional percentage units of protein.

Under these drylot conditions, levels of 16, 13, and 10 per cent protein for the periods of growth from weaning to 75, 75 to 150, and 150 to 200 pounds, respectively,

produced growth rates equal to and greater than those obtained with either 2 or 4 added percentage units. With 10 milligrams of aureomycin added per pound of ration, the protein level series of 14, 11, and 8 per cent produced growth rates equal to that obtained with 6 per cent more protein.

Corn alone, with a protein content of approximately 8 per cent, supplemented with vitamins and minerals, resulted in a daily gain of 1.54 pounds during the period from 150 to 200 pounds live weight, while with the addition of 10 milligrams of aureomycin per pound of ration the daily gain was 1.88 pounds. Forty-one pounds less feed were required per 100 pounds of gain in the presence of the antibiotic during this period.

This same type of ration, with and without aureomycin, was definitely inadequate for pigs from weaning to 75 pounds live weight. These pigs averaged 37 pounds at the start of the feeding period and after eight weeks had gained only an average of 0.32 pound per day. The diet appeared to be unpalatable, and the reduced feed intake accentuated the inadequacy of the ration. The addition of enough soybean oil meal to raise the protein per cent from 8 to 12 resulted in a ration which produced 0.84 pound greater daily gain and which required 318 pounds less feed for each 100 pounds of gain. When vitamin $B_{12}$ and the antibiotic aureomycin were added to the

1 a. Chairman of Committee, Damon V. Catron, Dept. of Animal Husbandry.
   b. Doctoral Thesis No. 1373. Submitted March 13, 1953.
2 a. B.S. University of Illinois, Urbana, Illinois, 1949.
   M.S. Ibid., 1950.
   b. Graduate Assistant, Agricultural Experiment Station.

latter ration, growth response and feed efficiency were further improved.

When pigs were fed the same protein levels (10, 12, 14, 16, 18 or 20 per cent) from weaning to 200 pounds live weight, 10 per cent protein levels were inadequate for optimum growth whether fed with or without either aureomycin or terramycin at 5 milligrams per pound of ration. In the absence of an antibiotic, 16 and 18 per cent protein level rations produced the most rapid rates of gain. In the presence of either aureomycin or terramycin, the most rapid gains were obtained on those rations containing 14 per cent protein. In this experiment, from weaning to 75 pounds live weight, those pigs receiving terramycin gained significantly faster than the pigs not receiving the antibiotic. When the pigs had reached 200 pounds, however, there were no significant differences due to antibiotic treatment. Considering the different protein levels fed, growth rates increased significantly with increase in protein level up to 14 per cent, and then decreased slightly on the higher protein levels.

Hogs from each of the protein levels fed, except 20 per cent, from weaning to market weight, were slaughtered and the following measurements were recorded: back-fat depth (both live probe and carcass measure), specific gravity, per cent lean cuts, weight of leaf fat, area of loin muscle, and carcass length. Of these measurements, specific gravity values and per cent lean cuts were the most indicative of a carcass composition. Thickness of back-fat was not sufficiently sensitive to use as a criterion for measuring carcass fatness.

Neither aureomycin nor terramycin adversely affected the quality of the carcass of hogs slaughtered at a live weight of approximately 200 pounds. There were no detectable differences between the antibiotic and non-antibiotic treatments. The protein level of the ration did affect the proportion of fat to lean. Considering the specific gravity values, there was a significant increase in values from the 10 per cent protein level up to the 16 per cent, and then a slight decrease at the 18 per cent protein level. Although not significant, the per cent lean cuts values supported this trend, indicating an inverse relationship of protein level in the ration to fat content of the carcass.

Data from 128 Duroc pigs individually fed in wire-bottom cages indicated that 10 per cent protein level corn-soybean oil meal rations were nutritionally inadequate for the period of growth from weaning up to 75 pounds. The addition to these rations of a synthetic DL-lysine, 40 per cent L-lysine, did not improve growth rate or feed efficiency. In fact, when 0.1 per cent L-lysine equivalent was added there appeared to be a decrease in palatability.

With the 12 per cent protein level rations, however, satisfactory growth rates and feed efficiencies were obtained. When 0.069 per cent L-lysine equivalent was added to this protein level, average daily gains were significantly increased and 21 pounds less feed were required for each 100 pounds of gain. This strongly supported the supposition that in the 10 and 12 per cent protein level corn-soybean oil meal rations lysine was the primary limiting amino acid.

Calculated biological values from the nitrogen balances determined on the pigs receiving the 12 per cent protein rations did not give a clear cut picture of the effect of lysine supplementation upon the utilization of the protein consumed. With the addition of 0.017 per cent L-lysine equivalent an apparent decrease in nitrogen utilization occurred. With 0.034 or 0.069 per cent addition of the amino acid higher biological values were obtained than were realized from the basal 12 per cent protein ration. No significant differences existed, but the trend toward higher values with increased lysine was evident.

The biological values obtained while the animals had feed and water ad libitum were significantly higher than when the animals received water ad libitum and feed at the rate of 1.5 pounds twice daily. The reason for this was not readily apparent.

The presence of 10 milligrams of aureomycin per pound of ration did not affect daily gain, feed efficiency, feed consumption, or biological values.

## MASS SPECTROMETRIC DETERMINATION OF LATENT HEATS OF METALS[1]

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A mass spectrometric technique has been developed which permits the measurement of latent heats of vaporization and the determination of transition temperatures and energies for solid to solid and solid to liquid phase changes in metals at high temperatures. The technique is applicable to a number of metals whose first ionization potentials are less than 6.5 volts and whose vapor pressures are greater than $10^{-6}$ millimeters of mercury at a temperature of $1200°C$. The technique of a modification of the Knudsen effusion method of measuring vapor pressures.

The metal under study is heated in the bottom of a closed tantalum crucible and the metal vapor is allowed to effuse out through a small orifice in the top. Some of the effusing atoms strike a hot tungsten filament and are immediately evaporated. Some of the atoms become ionized in the evaporation process. These ions are analyzed and the ion current is measured in the mass spectrometer. Under constant conditions in the instrument the measured ion current of the metal under study is strictly proportional to the vapor pressure in the effusion crucible.

The vapor pressure and the crucible temperature are related to the latent heat of vaporization by the well known thermodynamic equation

$$\frac{d \ln P}{d \frac{1}{T}} = \frac{- \Delta H_T}{R}$$

where P is the saturated vapor pressure at temperature T, $\Delta H_T$ is the heat of vaporization at temperature T, R is the gas constant, and T is the absolute temperature. Since the ion beam current in the mass spectrometer is maintained strictly proportional to P, it follows that, in the above equation, the ion beam current I can be directly substituted for P. Therefore a plot of ln I as a function of $1/T$ gives a curve whose slope is the quantity $\Delta H_T/R$

from which the heat of vaporization is found. The curve can be approximated by a straight line in the short interval of T over which a set of experimental data is usually taken.

Phase transitions in the condensed state are found by noting the temperature of the crucible at which the ion current and consequently the vapor pressure remain constant for a short time during cooling or heating. This constant ion current results from the constant temperature of the metal maintained by the energy absorbed or released in the transition process.

The metals used in this investigation were aluminum, praseodymium, and neodymium. The aluminum was stated by the supplier to be 99.75 per cent pure. Spectrographic analysis of the praseodymium and neodymium showed the presence of minute quantities, less than 0.1 per cent, of other metals, principally other rare earths.

An average latent heat of vaporization of aluminum metal was found from six determinations to be $78.70 \pm 0.39$ kilocalories per mole at a temperature of $1059°C$. This determination is in agreement within experimental error with a single previous determination made using a controlled boiling point method at $1676°$ C. No other direct experimental values were found in the literature.

The heat of vaporization of praseodymium metal was measured and values were found which agreed within experimental error with a previously reported value of $79.5 \pm 1.1$ kilocalories per mole. However, under some conditions of sample treatment anomalous values were obtained. The melting point phase transition was observed at a temperature of $919 \pm 2.5°C$.

The heat of vaporization of neodymium metal was found to be $69.3 \pm 0.4$ kilocalories per mole at $1075°C$ and $72.9 \pm 0.5$ kilocalories per mole at $963°C$. No previous measurements were found in the literature. A phase transition in the condensed state was found to occur at a temperature of $1019 \pm 2.5°C$. This transition had not been previously reported. Others at this laboratory have shown that this transition is the true solid to liquid phase change. From the above difference in the two heats of vaporization values the heat of fusion is found to be $3.6 \pm 0.7$ kilocalories per mole. A solid

1 a. Chairman of Committee, Donald B. Hudson, Dept. of Physics.
   b. Doctoral Thesis No. 1337. Submitted October 2, 1952.
2 a. B.S. Case Institute of Technology, Cleveland, Ohio, 1947.
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to solid phase transition was observed in neodymium at a temperature of $869 \pm 2.5°C$.

The mechanism of ionization by evaporation from the surface of the hot filament was of considerable interest in the development of the mass spectrometric technique. The efficiency of the ionization process for a given metal determines the practicability of the application of the

method. In addition, the present technique, when used in conjunction with the theory of surface ionization, permits the determination of unknown first ionization potentials, provided the work function of the surface is known. Work of this nature yielded values of the first ionization potentials of praseodymium and neodymium of 5.4 volts and 5.5 volts, respectively.

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## INHERITANCE OF RESISTANCE TO CERTAIN PHYSIOLOGIC RACES OF LOOSE SMUT, USTILAGO NUDA (JENS.) ROSTR., IN WINTER BARLEY[1]

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Objectives of this study were to determine the mode of inheritance of resistance to specific physiologic races of Ustilago nuda in certain winter barley crosses and to determine if there were associations between resistance and morphological characters. From a long-time point of view, the ultimate objective was to obtain segregates of value for commercial production and/or further use as breeding stocks. A major portion of this study was conducted as a part of the barley improvement program of the Department of Agronomy, Oklahoma Agricultural Experiment Station, Stillwater, Oklahoma.

At the inception of this research little information was available on the reaction of winter barley varieties to specific physiologic races or collections of loose smut, U. nuda. Seven winter barley varieties that possessed either smut resistance or adaptation in Oklahoma were selected as parents and nearly all possible crosses among them were made to study mode of inheritance of smut resistance.

Inoculum of eight tentatively designated races of U. nuda was furnished by Dr. V. F. Tapke, Division of Cereal Crops and Diseases, U. S. Department of Agriculture, Beltsville, Maryland, in the form of seeds from hand-inoculated florets. Based on the smut reactions of the parent varieties seven sets or cross-race combinations were selected for the inheritance study. Parent and $F_2$ plants were inoculated with appropriate races by means of

a continuous flow hypodermic syringe with a spore suspension in a 2 per cent dextrose solution.

Emergence of the fall-planted inoculated seed from $F_2$ and parent plants averaged 75.3 per cent. Correlation coefficients were calculated and all but two coefficients between seed set and emergence were positive. Only two of these values were significant. Seed set and infection percentages were significantly correlated in only three instances. Most correlation coefficients between emergence and infection percentage were negative and several exceeded the 0.01 or 0.05 level of significance.

Daily heading notes indicated no appreciable difference in time of heading between smutted and healthy plants.

Reaction of parent varieties to each of the 8 races in 1952 differed somewhat from their reaction in 1950. Harbine, which had given a resistant reaction to most races in 1950, showed susceptibility to at least 5 races. Results by other workers and from this study indicate that some of these races are very similar if not the same.

Analyses of variance indicated no appreciable difference in emergence among lines of a given parent with one exception. However, highly significant differences existed among lines in four of the seven hybrid combinations.

Analyses of data on smut infection showed no significant difference among lines of any resistant parent. Lines from the susceptible parent Ward were significantly different in all five sets in which Ward occurred. Highly significant differences among lines were obtained for the hybrids of each of the seven cross-race combinations.

1 a. Chairman of Committee, I. J. Johnson, Dept. of Agronomy.
  b. Doctoral Thesis No. 1358. Submitted March 3, 1952.
2 a. B.S. University of Nebraska, Lincoln, Nebr., 1940.
  M.S. Ibid., 1942.

Resistant reactions of $F_1$ plants from crosses in which N.C.H. 26 was the pollen parent indicate that resistance in N.C.H. 26 was dominant, and substantiate the findings of previous workers who reported that the reaction of an $F_1$ plant was dependent upon the nature of the embryo rather than the maternal tissue.

Infection percentages were based on the total number of smutted and clean plants in each line. Partially smutted plants were considered only half smutted for the resistant parent and hybrid lines in four sets since the total numbers of smutted and healthy heads on the "partials" were almost equal.

No genetic interpretation could be made for the N.C.H. 26 x Ward cross inoculated with race 6.

Resistance of Dohadak to race 4 in the cross with Ward appeared to be due to relatively few genes. An acceptable fit was found to a 9 resistant to 7 susceptible ratio.

The crosses N.C.H. 26 x Dobaku and N.C.H. 26 x Dohadak were inoculated with race 7. When the infection range of the resistant parent, N.C.H. 26, was used to establish the resistant class for the $F_3$ lines in the Dobaku cross, then an acceptable fit to a 9 resistant to 7 susceptible ratio was obtained. However, this method of establishing the resistant class may not be justifiable since the $F_3$ distribution indicates a more or less continuous varia-

tion. In the cross with Dohadak, when the infection range of N.C.H. 26 was used to delimit the combined homozygous and heterozygous resistant class, an acceptable fit to a 3 resistant to 1 susceptible ratio was obtained. However, this would mean that the segregating class would fall within the infection range of the resistant parent and such an explanation does not appear sound.

Hybrid and parent lines of the cross Harbine x Ward were tested against races 3, 4, and 6 but both parents proved to be susceptible to races 3 and 6. By using the point where the distribution curves of Harbine and Ward intersect (25 per cent infection) to divide the $F_3$ lines into classes, a good fit to a ratio of 9 susceptible to 7 resistant was obtained from the inoculations with race 4. However, since the distribution curve for the $F_3$ lines does not show a definite break, this classification and possible genetic interpretation may not be justified.

All morphological characters studied appeared to be independent of reaction to loose smut although the probability value for the association between smut reaction and seed covering was only 0.05 to 0.10.

Individual $F_3$ plants were saved from many of the lines which showed a resistant reaction. Certain of these are being grown for further selection of desirable agronomic types having resistance to one or more races of loose smut.

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## ANOPLURA AND MALLOPHAGA INFESTING MAMMALS OF IOWA₁

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The known Anoplura and Mallophaga affecting the mammals of Iowa number 61 species and subspecies. Of this number, 36 belong to the order Anoplura, the sucking lice, and 25 to the order Mallophaga, the chewing lice. The Anoplura are distributed among 4 families and 11 genera and the Mallophaga among 3 families and 13 genera. Lice are of considerable economic importance, since some species are capable of transmitting disease, some

serve as intermediate hosts for other parasites, and all species when abundant may cause irritation and loss of weight to the host.

The chief purpose of this work it to bring together the records of lice species which occur on mammals in this region, to present their synonymy together with a brief description of all species concerned, and to develop a usable well-illustrated key to these species.

Various sources were utilized in compiling the Iowa list. The literature was examined for records from Iowa host species. Museum skins were inspected for lice, and field collecting of mammals was done. In addition, a study was made of various mounted slide collections of other workers.

This is not a revisionary work. The tax-

onomy is conservative and does not depart radically from that of accepted present-day authorities. There are noted a number of instances where the taxonomy is still unsatisfactory, but must await later revision.

The family Haematopinidae of the order Anoplura is represented by one genus, Haematopinus Leach, which includes 4 species that occur on domestic animals. One of these has not been reported from Iowa but is differentiated because of its possible extension into this area.

The Hoplopleuridae is represented by three subfamilies, Enderleinellinae, Hoplopleurinae, and Polyplacinae. In the first subfamily, 4 species of Enderleinellus Fahrenholz, all ectoparasites of the family Sciuridae, are included. One species of Haematopinoides Osborn from the mole and 6 species of Hoplopleura Enderlein, with a broad distribution among the Rodentia, comprise the representatives of the Hoplopleurinae. The Iowa Polyplacinae consist of 4 species of Polyplax Enderlein on members of the Muridae and Cricetidae and three species of Neohaematopinus Mjöberg on the Sciuridae.

The genera Haemodipsus Enderlein, Linognathus Enderlein, and Solenopotes Enderlein, with 2, 6, and 3 species, respectively, represent the family Linognathidae. Haemodipsus occurs on rabbits and hares of the family Leporidae, Linognathus on domestic animals of the order Artiodactyla with the exception of one species found on the dog, and Solenopotes on deer and cattle, families Cervidae and Bovidae, respectively.

The family Pediculidae is divided into the subfamilies Pediculinae and Phthirinae which are represented by Pediculus Linnaeus and Phthirus Leach, respectively. These genera include the sucking lice of man.

The suborder Amblycera of the Mallophaga contains representatives of the families Boopidae and Gyropidae. The first family contains a single species of the genus Heterodoxus Le Souëf and Bullen, found on the dog. The latter family is represented in Iowa by the two genera Gyropus Nitzsch and Gliricola Mjöberg each having a single species found on the guinea pig.

The other 22 species of Mallophaga present in Iowa are distributed in 10 genera of the family Trichodectidae. Trichodectes Nitzsch contains species from the dog and raccoon. The 4 species of Neotrichodectes Ewing are restricted to members of the family Mustelidae. Two species of Stachiella Kéler are found on Mustela species. The Suricatoecus Bedford is represented by one species on Canidae, Feli-

cola Ewing by two species on Felidae, Geomydoecus Ewing by one species on Geomyidae, and Eutrichophilus Mjöberg by a species on porcupines of the family Erethizontidae.

Six species are considered in the genus Bovicola Ewing, 5 of which are economically important species on domestic animals. One species of Holakartikos Kéler from the goat and two Tricholipeurus Bedford species from deer complete the known representatives of the Trichodectidae of Iowa.

Some of the important key characters for the identification of the Anoplura are the thoracic sternal plate, the paratergal plates, the second abdominal sternite, and the structures of the genitalia. The female genitalic characters found to be of most value are the shape and bristling of the gonopod and the apical lobe. In the male, the shape of the genital plate, the shape and bristling of the genital tubercle, and the shape of the parameres are of paramount importance in distinguishing the species.

For the Mallophaga, the spiracles, the shape of the head, the antennae, the bristling of the abdomen, and the characters of the genitalia are valuable diagnostic characters. The female gonopod usually offers good generic characters and is very useful in the identification of species. The sclerotized parts of the male genitalia, parameres, basal plate, endomeral piece, and the aedeagus, offer valuable key characters.

Fifteen plates containing 146 figures are contained in the thesis. One of these plates depicts the structural details of an anopluran, Neohaematopinus sciurinus Mjöberg, showing a labelled full dorsal-ventral view. Another plate shows the structural parts of a typical trichodectid, Trichodectes canis (de Geer). In the other plates, only certain structural details of value in identifying the various species, such as genitalia, head, paratergites, or sternal plate, are illustrated.

Keys for the ready identification of families, subfamilies, genera and species of both the Anoplura and Mallophaga of Iowa are included. Each species is accompanied by the type-host designation, a description which includes the more important recognition characters, and a brief general discussion of its distribution, Iowa records, economic importance, and systematic position.

A host-index to the lice found on mammals of Iowa is also presented, along with tables depicting the distribution and host association of the lice on the various groups of mammals.

## ALUMINUM-VANADIUM SYSTEM[1]

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The nature of the aluminum-vanadium system has been reported on the basis of thermal, microscopic, chemical and X-ray evidence. The system contains six different solid phases at ambient temperatures: the four intermediate phases being peritectic in nature. Phase properties are summarized in Table 1.

The effect of composition upon density can be represented by a series of straight lines; the phase boundaries of the aluminum-vanadium system seem to have some correlation with the discontinuities in slope of these straight lines. The addition of 20 weight per cent aluminum has little effect on the hardness of either as-cast or cold-worked vanadium. All hardness values observed for alloys containing up to 20 per cent by weight aluminum fell within 10 points of 60 on the Rockwell "A" scale. On the other hand, the addition of vanadium to aluminum, has a profound effect on the hardness of the metal. The arc-melted alloys were cold pressed under 50 thousand psi. and reduced as much as 50 per cent in thickness. A surprising feature of these

alloys is that upon annealing in vacuo at 600°C for 24 hours the cold-worked metal became harder rather than softer. This is attributed to the development of a brittle peritectic compound (such as $Al_{11}V$) whose formation was suppressed during the rapid cooling of the arc-melting furnace.

Aluminum will dissolve less than 0.5 per cent vanadium in solid solution, while vanadium will dissolve up to 25 per cent aluminum at room temperature. A maximum solid solubility of 35.3 per cent aluminum in vanadium occurs at 1670°C. Of the four intermediate phases, only $\delta$ (Al-V) shows an appreciable solid solubility range (47 to 55 per cent vanadium at 1360°C); this solubility range decreases with decreasing temperature and is almost negligible at room temperature. The solid solution phase, (V), is the primary phase to crystalize from the melt in all alloys containing more than 50 per cent vanadium.

The crystal structure of each phase was pursued short of quantitative intensity measurements, and an unambiguous formula is provided for each of the intermediate phases. A correlation of the various phase structures indicates that a marked tendency toward super-lattice formation exists in the aluminum-vanadium system. An aluminum atom exhibits a preference for four nearest vanadium neighbors and four nearest aluminum neighbors arranged tetrahedrally.

1 a. Chairman of Committee, Harley A. Wilhelm, Dept. of Chemistry.
   b. Doctoral Thesis No. 1384. Submitted May 12, 1953.
2 a. B.S. Loyola University, Chicago, Illinois, 1948.
   b. Graduate Assistant, Institute of Atomic Research.

Table 1. Summary of Phase Properties

| Phase | (Al) | $\alpha$(Al-V) | $\beta$(Al-V) | $\gamma$(Al-V) | $\delta$(Al-V) | (V) |
|---|---|---|---|---|---|---|
| Formula | | $Al_{11}V$ | $Al_6V$ | $Al_3V$ | $Al_8V_5$ | |
| Crystal sym. | F.C.C. | F.C.C. | Hex. | F.C.T. | B.C.C. | B.C.C. |
| Lattice const. (Å) | $a_o = 4.0496$ | $a_o = 14.586$ | $a_o = 7.718$ | $a_o = 5.3434$ | $a_o = 9.207$ | $a_o = 3.031$ |
| | $a_o = 4.0481^b$ | | $c_o = 17.15$ | $c_o = 8.3257$ | | $a_o = 3.069^b$ |
| Space group | $T_h^4 - Fd3$ | | $D_{3h}^4 - C\bar{6}2c^c$ | $D_{4h}^{17} - F4/mmm$ | $T_d^3 - \bar{I}43m$ | |
| Atom/unit cell | 4 | 192 | 56 | 16 | 52 | 2 |
| Structure[d] | $A_1$ | ___[e] | | $Do_{22}$ | $D8_2$ | $A_2$ |
| Paritectic temp. | 660°C | 685°C | 735°C | 1360°C | 1670°C | 1825°C[a] |

[a]Melting point of pure vanadium.

[b]Lattice constants of (V) saturated with $\delta$(Al-V) and (Al) saturated with $\alpha$(Al-V).

[c]Highest symmetry group of three possible groups.

[d]Strukterbericht designation.

[e]No analogous compound reported.

# HALL EFFECT AT LOW TEMPERATURES FOR RARE EARTH METALS[1]

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Department of Physics

The Hall effect in metallic lanthanum, cerium, praseodymium, neodymium, dysprosium, and erbium was studied in the temperature range from $20.3°$K. to $300°$K. Gadolinium, erbium, and dysprosium, which become ferromagnetic, were studied quantitatively only above their respective Curie temperatures, with gadolinium being studied from $30°$C. to $350°$C. Below the Curie temperatures, only the sign of the Hall effect was determined.

The Hall effect was measured using an a.c. method operating at 100 c.p.s. A high gain, low noise, narrow band amplifier was used to amplify the Hall voltage. Temperature control was achieved by varying the boiling rate of either liquid nitrogen or liquid hydrogen and passing the evaporated gas over the sample. Temperatures throughout the range from $20.3°$K. to $300°$K. could be attained in this manner.

Hall coefficients were measured at various temperatures and the results were plotted as functions of temperature for each metal. Results of the investigation for each metal are summarized below.

1. Lanthanum exhibited an unknown crystal structure and the magnitude of the Hall coefficient was strongly dependent on heat treatment. As the metal was received, its Hall coefficient at room temperature was $-0.35 \times 10^{-12}$ volt-cm/amp-oersted; after annealing it was about $-0.8 \times 10^{-12}$ volt-cm/amp-oersted, and it was changed by further annealing. The Hall effect showed some rather large variations in magnitude with temperature but remained negative in sign at all temperatures studied.

2. Cerium showed only the face-centered cubic structure at room temperature after either annealing or cycling to low temperatures. The room temperature value of the Hall coefficient after annealing was $+1.81$

1 a. Chairmen of Committee, Sam Legvold, Dept. of Physics, and Frank H. Spedding, Dept. of Chemistry.
   b. Doctoral Thesis No. 1362. Submitted March 6, 1953.
2 a. B.S. Iowa State College, Ames, Iowa, 1948.
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$\times 10^{-12}$ volt-cm/amp-oersted and this was reproducible for various samples to better than 1 per cent. The value at room temperature after the first and subsequent cycles to low temperatures was $+1.41 \times 10^{-12}$ volt-cm/amp-oersted. Reannealing raised this back up to the higher value.

The Hall coefficient, which was positive at all temperatures, showed a thermal hysteresis with sharp changes in magnitude near $100°$K. on cooling and near $180°$K. on warming. These sudden changes could be considered evidence for the postulated shift of a 4f electron to a 5d state.

3. Praseodymium was of undetermined structure. The room temperature Hall coefficient was $+0.709 \times 10^{-12}$ volt-cm/amp-oersted and was not sensitive to annealing and cooling. There was little temperature variation of the coefficient except below nitrogen temperatures and this may be due to a magnetic effect.

4. Neodymium was found to have a room temperature Hall coefficient of $+0.971 \times 10^{-12}$ volt-cm/amp-oersted which was not affected by annealing and cooling. A rather complex temperature dependence was found at the lower temperatures with a small maximum near $70°$K. and a sudden rise near $20°$K. Both may be due to magnetic effects.

5. Gadolinium was studied in the temperature range from $30°$C. to $350°$C. and the Hall effect was negative throughout. After taking account of the extraordinary effect which is associated with magnetization, a value was obtained for $R_0$, the ordinary coefficient, of $-0.4 \times 10^{-12}$ volt-cm/amp-oersted.

6. Dysprosium showed a negative Hall effect at room temperature and this increased in magnitude down to about $200°$K. below which temperature it decreased and reversed sign. This reversal was attributed to the extraordinary effect. An approximate value for the ordinary coefficient, $R_0$, was found to be $-1.0 \times 10^{-12}$ volt-cm/amp-oersted.

7. Erbium was found to have a negative Hall effect from room temperature down to $20.3°$K. The magnitude of the coefficient at room temperature was $-0.341 \times 10^{-12}$ volt-cm/amp-oersted.

## SOME APPLICATIONS OF ENGINEERING VALUATION-INDUSTRIAL ENGINEERING THEORY TO COST REDUCTION IN INDUSTRY[1]

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Department of General Engineering

An investigation was conducted, combining certain applications of the theory of engineering valuation and industrial engineering into an industrial training program. The program was designed especially to assist smaller industrial companies toward more effective cost reduction work. The purpose of the program was to secure company-wide cooperation in identifying and eliminating wasted costs from industrial products and processes. It had practical application to production planning and control, and to purchasing procedures. Problems of financial policy, selling methods, organizational changes within the company, methods of wage payment, and studies designed to make workers work harder were considered as outside the scope of this investigation.

The experimental procedure used to attain the objective was as follows: The personnel who could most effectively use the training were selected. Authority and re-

sponsibility of the trainees as a group were determined. Essential portions of the theory of engineering valuation and industrial engineering were selected, and parts not relevant to the accomplishment of the objective were excluded from the training program. Keeping in mind the limited facilities available for conduct of the program in smaller companies, training aids were examined, and those which might be used effectively were selected. A training manual was developed for the guidance of the personnel participating.

The training program was experimentally tested in two industrial plants. Following completion of the tests, an evaluation of the results was undertaken, together with description of new applications which have been made since the program was completed.

It was found that smaller industrial concerns could benefit financially by use of the training program. The training could be effectively undertaken within the plant, and without the use of elaborate training aids. Personnel with widely varied training and experienced backgrounds were able to participate effectively in the same training group. The training program appeared to act as a "catalyst" in securing improved inter-departmental cooperation by those participating, and it furnished a definite procedure which facilitated effective use of personnel in the problems investigated.

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   b. Doctoral Thesis No. 1413. Submitted June 5, 1953.
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## THE EFFECT OF VITAMIN $B_{12}$, COBALT, AND ANTIBIOTIC FEEDING ON THE COMPOSITION OF PORK TISSUE[1]

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Investigators in the field of Animal Husbandry have contributed vast volumes of

1 a. Chairman of Committee, Damon V. Catron, Dept. of Animal Husbandry.
   b. Doctoral Thesis No. 1418. Submitted June 6, 1953.
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information on the effect of rations on the growth performance of pigs, but limited data is available on the effects of dietary supplements on tissue composition. These studies were designed to study the influence of feeding vitamin $B_{12}$, cobalt, phosphorus, and antibiotics on the composition of pork tissue.

In the first experiment, two groups of twelve pigs each were fed and watered ad libitum from weaning to 100 pounds in individual wire floored crates. The pigs were selected from sows that were main-

tained throughout lactation on corn-soybean oil meal rations fortified with only vitamins A and $D_2$ and minerals containing no added cobalt. When placed on experiment, the pigs were fed a purified basal ration, consisting of Ortho 220 protein, dextrinized cornstarch, cornstarch and corn oil fortified with methionine, a complex vitamin mixture containing no vitamin $B_{12}$, C.P. minerals, and trace minerals containing no cobalt. This basal ration was deficient in vitamin $B_{12}$ but not deficient in cobalt, since it contained 0.10 ppm. of cobalt, To this ration vitamin $B_{12}$, when added, was added at the rate of 10 micrograms per pound of ration, and cobalt, when added, was added at the rate of 3 milligrams per pound of ration. One group of pigs received 100 milligrams each of aureomycin hydrochloride, streptomycin, terramycin hydrochloride, procaine penicillin G, and sulfathalidine per pound of final ration.

The growth and performance of all pigs on all rations was quite satisfactory and no nutritional deficiencies were produced. Growth was improved by the addition of vitamin $B_{12}$ in the absence of antibiotics. The apparent vitamin $B_{12}$ content of the liver, spleen and kidney was increased by the addition of vitamin $B_{12}$ to the ration, but the vitamin $B_{12}$ content of the loin muscle was not affected. When a combination of vitamin $B_{12}$ and cobalt was added to the basal ration, the vitamin $B_{12}$ content of the glandular tissues was lower than when vitamin $B_{12}$ was added to the ration.

The addition of cobalt, 3 ppm., to the basal ration did not improve growth, although more cobalt was found in the livers of the pigs receiving additional cobalt.

In the absence of antibiotics, the total phosphorus in the tissues increased when vitamin $B_{12}$ was added to the ration.

The carcass quality, as measured by length of body, back-fat thickness, specific gravity, and per cent of lean cuts was not appreciably influenced by these treatments. The feeding of a mixture of antibiotics at high levels did not influence the vitamin $B_{12}$ content of the tissues studied.

Under the conditions of these experiments, the feeding of a combination of antibiotics, 500 mg. per pound of ration, did not appreciably effect the microbial populations of the intestinal tract; if anything, the total count was increased.

In the second experiment, twenty-four pigs were individually fed from weaning to 95 pounds. The basal ration consisted of soybean oil meal, dextrinized cornstarch, cornstarch, and corn oil fortified with minerals and trace minerals, and all known vitamins except vitamin $B_{12}$. This basal ration contained 0.50 per cent calcium and 0.25 per cent phorphorus. Additions of di-calcium phosphate, at the expense of some calcium carbonate and starch, to this low phosphorus ration permitted developing a high phosphorus ration containing 0.50 per cent phosphorus. Vitamin $B_{12}$, when added, was added at the rate of 10 micrograms per pound of ration. One-half of the pigs received an antibiotic supplement which was the same mixture and was fed at the same level as in the preceding study. During this experiment, six pigs, on various ration treatments, were lost, one was diagnosed as having rickets and the other five as having symptoms of leptospirosis.

The growth and performance of all pigs, with the exception of those animals removed because of disease, was quite satisfactory and no nutritional deficiencies were produced. Growth was improved by the addition of the antibiotics to the rations. The feeding of phosphorus at the 0.50 per cent level improved both rate and efficiency of gain as compared to the feeding of phosphorus at the 0.25 per cent level. The feeding of antibiotics produced fatter carcasses as measured by back-fat thickness. The feeding of phosphorus produced leaner carcasses as measured by specific gravity; however, no difference in back-fat thickness resulted.

The feeding of vitamin $B_{12}$ resulted in a decrease in liver weights and adrenal weights.

The phosphorus content of the liver was increased as a result of feeding vitamin $B_{12}$. No difference in liver phosphorus was noted due to feeding phosphorus or a mixture of antibiotics.

# A REVISION OF THE NEARCTIC SPECIES OF FUNGIVORA MEIGEN (DIPTERA, FUNGIVORIDAE)₁

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Fungivora Meigen is found on all the continents and is a common genus in North America. The Nearctic species have not been treated comprehensively for more than 40 years and the existing systematic literature is inadequate for their accurate identification.

A taxonomic study was made of the Nearctic species of the genus. Over 9,500 Nearctic and 500 Palaearctic specimens were studied. This material was obtained from 31 institutional and 18 private collections in North America and from five institutional and three private collections in Europe. The most important depositories of the Fungivora used in the study are the British Museum, California Academy of Sciences, Canadian National Collection, Cornell University, Museum of Comparative Zoology at Harvard College, Iowa State College, University of Massachusetts, Academy of Natural Sciences of Philadelphia, United States National Museum, and the personal collection of the writer.

Ninety-six Nearctic species are recognized, and a description of one additional unrecognized species is included. Forty-six new species are characterized. Thirty-three new cases of synonymy are established in the genus. Two other names previously included are made synonyms of a species in another genus. One species is definitely transferred to another genus

for the first time. Comparisons of European and Nearctic specimens showed that 21 species of North American Fungivora also occur in Europe. Twenty of these 21 are recorded from either Alaska or Canada, or both. Only four of the 21 have previously been recognized as occurring in both the Nearctic and Palaearctic regions.

Several characteristics previously unused for diagnosis of North American Fungivora were found to be of taxonomic value. The numbers of setulae on the radial vein before the radial sector and on the medial vein before the radial-medial crossvein are frequently helpful in species recognition. The ratio of height to length of the anepisternum shows considerable variation within the genus. Some species possess a mid tibial anterodorsal bristle which is absent in other species. The length of the setae on the central portion of the posterior surface of the hind coxa is sometimes useful in identification. Within a species the coloration of the hind tibial setulae is fairly constant, nearly all the setulae being dark brown in some species, while others possess pale setulae on some areas of the tibia.

The primary criterion used for distinguishing between species is the presence of differences in the male terminalia. Some of these structures are figured for all except two of the recognized species. The female cerci of 18 species are illustrated. Several other figures of characters of taxonomic value are included.

A satisfactory scheme for dividing the genus into subgenera was not found. For purposes of convenience in the construction of the keys, the genus is divided into six artificial groups. Some species assigned to one group are probably more closely related to species in other groups on the basis of certain characteristics, especially the male terminalia.

# LIPID REQUIREMENTS OF THE YOUNG DAIRY CALF₁

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The dietary essentiality of unsaturated fatty acids for young dairy calves was studied by feeding a lipid-free, semi-synthetic milk containing vitamin-test casein, C. P. Lactose, minerals and vitamins. Five of the calves on the lipid-free ration received lipid supplementation subsequent to eight weeks of age; three other calves in this group received lipid supplementation after the twelfth week. Twelve other calves received a similar diet plus various lipids from birth. Weight records were kept and clinical observations were made daily on each calf. Blood plasma samples were analyzed for total fatty acids, "Allen fat", phospholipids and for linoleic, linolenic, and arachidonic acids.

Fat deficiency syndromes first appeared in the calves after six weeks on the lipid-free diet, and were quite severe in 50 per cent of the calves after about eight weeks. The calves receiving no fat had a scaly dandruff which was most concentrated across the shoulders and along the back and tail. The hair remaining on the body was long, dry and lacked the luster of the hair on the calves receiving lipids. Also, alopecia was occasionally noted on the neck and tail of calves on the lipid-free diet. Diarrhea became more common as the calves approached 56 days on the lipid-free milk.

After various lipids were introduced into the rations of calves on the lipid-free diet at 8 and 12 weeks the dandruff condition was alleviated, the skin became more oily, a smooth hair coat began to appear, the calves seemed to become more alert. The loss of hair ceased and new hair soon appeared on denuded areas. Satisfactory response to 15 g. of methyl esters and 15 g. of pork liver fat were observed although the responses were not so spectacular as when butter oil or hydrogenated soybean oil plus lecithin was fed.

Gain in weight of calves on the lipid-free

ration was greatly retarded. The mean weight gain from 0 to 56 days was 10.9 pounds for calves fed the lipid-free milk as compared to 30.4 for those which received an isocaloric diet containing 1.8 per cent hydrogenated soybean oil and 0.2 per cent lecithin. Inclusion of only hydrogenated soybean oil promoted greater weight gains than the lipid-free diet but this fat singly was not so effective as when lecithin also was included. Results indicated that lecithin is ineffective as the sole lipid source.

The mean blood plasma "Allen fat" values during the period from 21 to 56 days were 23 and 162 mg. per 100 ml. for calves on lipid-free and lipid containing rations, respectively. The blood fat levels increased very rapidly when lipids were introduced into the rations of calves subsequent to the lipid-free ration. Calves receiving hydrogenated soybean oil as the only lipid supplement had lower total plasma "Allen fat" values than did calves receiving hydrogenated soybean oil and lecithin.

Blood plasma phospholipids were consistently lower in the calves on the lipid-free diet. The mean phospholipid values of calves on the lipid-free ration and on the lipid-containing ration during the 21 to 56 day period were 54 and 138 mg. per cent, respectively. It is also noteworthy that calves which had received hydrogenated soybean oil plus lecithin had slightly higher phospholipid values than calves which had received only hydrogenated soybean oil.

The mean total fatty acid values during the period from 21 to 56 days were 22 and 143 mg. per 100 ml. for calves on the lipid-free milk and lipid-containing milk, respectively. During the same period, the linoleic, linolenic, and arachidonic acid values, respectively, expressed in mg. per cent, were 75.6, 1.8, and 4.1 for calves fed lipids and 2.2, 0.3, and 1.3 for calves on the lipid-free diet. The plasma linoleic acid values of calves on the lipid-free ration declined sharply after one week and remained consistently low throughout the experimental period. Linoleic acid values were significantly lower in the lipid-free group, and arachidonic values were only slightly lower in the lipid-free group. The linolenic acid values, however, were low and variable in every instance regardless of diet.

## DEFOLIATION OF COTTON[1]

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Cotton defoliation is the removal of leaves by chemical treatment, a relatively new cultural practice brought to prominence by the advent of harvesting machinery. Defoliation is necessary for successful machine harvesting, but also produces other benefits such as aiding insect control, preventing boll rot, and hastening the opening of bolls. Defoliation trials have been in progress for a little over a decade, but, overall, the previous attempts have been too variable to be satisfactory. The study reported here involved field and greenhouse experiments in an attempt to obtain an indication of the nature of chemically induced abscission.

Applications of commercial and experimental defoliants were made by airplane, tractor, and hand sprayer, and by immersion of blades or distal tips of petioles. The morphology of natural and induced abscission was studied from sections of cotton nodes, and the effect of maturity, temperature, girdling, and anti-auxins on the abscission of leaves or debladed petioles was studied.

It was noted that all of the compounds tested caused varying amounts of damage to the tissues. A few of the newer compounds stimulated leaf-fall with a minimum of killing but with pronounced color changes which are like the changes of senescence. It is thought that defoliants of this type will prove most satisfactory.

As has been a general observation in defoliation, leaf maturity was found to be the most critical factor in obtaining good results. When expanding leaves and mature leaves were treated, the immature leaves dropped more slowly, and 20 per cent fewer such leaves had dropped at the end of the experiment. In the field, anything which caused the plants to make excessive growth or set fruit irregularly, such as insect damage or dry weather,

reduced defoliation about 20 per cent. Relative fruitfulness also seemed to be important, as perfect defoliation was obtained only in heavily fruited, mature cotton.

Induced abscission was found to have a $Q_{10}$ of about 2 over the range from $20°C$. to $30°C$. From $10°C$. to $20°C$., the $Q_{10}$ was greater than 2, and at $5°C$. the defoliant used had no apparent effect on abscission. Temperature is critical in certain areas, such as the High Plains region of Texas, where growers usually wait two or three times longer for the leaves to fall as compared to warmer areas.

Induced and natural abscission appeared to be alike in morphology. The first sign of abscission, either naturally or chemically induced, was a break on the abaxial surface of the petiole base. The break usually extended inwardly to the vascular strand, but abscission beyond this point, although involving separation of intact cells, followed some cell division. It could not be determined which aspect of the process is the most important, but both phenomena are associated in good defoliation responses because only green, living petioles are ever completely severed.

Experiments with the treating of debladed petioles with certain anti-auxins and defoliants indicated that the anti-auxins used are ineffective abscission agents, whereas all defoliants tested promoted abscission of the petioles. Further tests, including the removal of a strip of bark above and below the node, showed that certain defoliants apparently move to the abscission zone and seemed to be abscission inducing agents per se.

The likeness of defoliation and natural abscission in terms of maturity requirement, temperature requirement, and morphology leaves no indication that the two processes differ. The apparent ineffectiveness of anti-auxins in inducing abscission is further evidence that the lack of auxin does not fully explain leaf-fall. Natural leaf-fall is known to follow senile changes in the blade, and it is thought that a thorough study of the physiology of senescence may help in determining the nature of basic defoliation processes.

VARIATION AND ITS EVALUATION WITHIN AND AMONG
STRAINS OF BROMUS INERMIS LEYSS[1]

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Agronomic performance of a number of
seed lots of different strains of smooth
bromegrass, Bromus inermis Leyss.,
was studied in replicated nurseries, space-
planted, broadcast alone, and broadcast
with alfalfa. The space-planted nursery
consisted of seed lots of Fischer, Lincoln,
Achenbach, and Elsberry, produced in dif-
ferent areas in the United States, together
with eleven other strains from the United
States and Canada, five introductions from
Turkey, and three clones. Individual plant
measurements were taken in this nursery
for fall vigor in the year of establishment,
hay vigor, height, spread, leaf width, re-
covery, and disease resistance. The broad-
cast nursery consisted of 34 entries and
was designed as a split-plot with planting
methods as whole plots and entries as sub-
plots. Two forage harvests were made in
1952 in this nursery to obtain a measure
of agronomic performance. In addition,
the first harvest of the brome-alfalfa mix-
tures was separated into grass and legume
components for a study of composition.
Thirty-two seed lots were common to all
methods of planting. Objectives were to
study plant-to-plant variability, extent of
genetic variation, and degree of relation-
ship among agronomic characteristics in
the spaced-planted nurseries, to compare
strain performance under the different
methods of planting, and to determine
whether genetic alterations had occurred
in any of the varieties as a consequence
of seed production in areas away from the
point of origin.

In the broadcast experiment entries dif-
fered significantly for first and second
harvest and for annual total yields of brome
sown alone. First harvest yields varied
from 1.46 to 2.26 tons of dry weight per
acre. Southern strains were superior to
those of northern origin at both harvests,
but actual differences in second cutting
yields were small. At the first harvest of

the grass-alfalfa mixtures, entries varied
significantly in quantities of grass produced
in combination with alfalfa. Percentages
of alfalfa ranged from 62.2 to 85.9 per
cent, with Mandan 404 the highest and
Fischer (Jensen) the lowest. The more
vigorous southern strains produced greater
quantities of grass in the mixtures than
intermediate and northern types. No sig-
nificant differences among entries were
found when first, second, and annual total
yields of the mixtures were considered.
It appeared that alfalfa tended to mask
bromegrass strain differences.

In the spaced-planted nursery highly
significant mean differences among entries
were obtained for all characters studied.
Southern strains exceeded northern strains
in mean fall vigor, hay vigor, height,
spread, and recovery. Superiority of
southern strains in capacity to establish
vigorous seedlings was especially out-
standing. Some seed lots of Lincoln and
Achenbach differed significantly in mean
fall vigor, hay vigor, and spread in com-
parisons with the experiment station stan-
dards. Fischer seed lots differed signifi-
cantly in rate of spread. However, all
seed lots of each of the four varieties per-
formed similarly with respect to yield in
all aspects of the broadcast experiment.
Thus, it was concluded that one or two
generations of seed production in areas
away from the source of origin had essen-
tially no effect on inherent forage produc-
tion capacity.

Relative plant-to-plant variability of
clones and of plants from cross-pollinated
seed was studied by analyses of variance
of arithmetic and log with-plot variances.
Entries differed significantly in variability
of fall vigor, hay vigor, height, spread,
and leaf width. Seed-derived plants exhi-
bited much more variability than the clones.
Estimates of genetic variation obtained by
comparison of mean-within plot variances
of clones with that of seed-derived plants
were 60, 71, 67, and 67 per cent for hay
vigor, height, spread, and leaf width, re-
spectively. More than one-half of the ob-
served total variability for fall vigor was
environmental in nature. These high esti-
mates of genetic variation indicate that
some genetic advance might be expected
by phenotypic selection for such characters.

Intercharacter associations were studied
by calculation of simple, genetic, and en-

vironmental correlation coefficients. Phenotypic associations of hay vigor with fall vigor, height, spread, and recovery were positive and highly significant ("r" values ranged from 0.757 to 0.945). It was concluded that spaced-plants can be evaluated adequately by assigning a single vigor score at hay stage. A low, non-significant negative association (r = -0.297) between hay vigor and leaf width was obtained. More detailed calculations of genetic correlations provided little additional useful information.

Methods of planting were compared by calculation of correlation coefficients and analyses of entries x methods of planting interactions. Interactions were non-significant for first cutting and total annual yields, indicating that seed lots performed similarly whether broadcast alone or with alfalfa. However, a significant interaction at the second cutting was obtained, indicating that entries reacted differentially to the two methods of planting at that time. First harvest yields of brome alone were significantly associated with the grass

fractions and with total first cutting yields of the mixtures (r = 0.580 and 0.349, respectively). A low correlation of 0.198 indicated little association between total annual yields of entries sown alone and with alfalfa. Variations in grass fractions appeared to be more important than alfalfa components in determining differences in total first harvest yields. Hay vigor and its associated traits observed in the space-planting were positively and significantly correlated with first and second cutting and total annual yields of brome sown alone in solid stands ("r" values ranged from 0.351 to 0.774). Hay vigor also was highly correlated with the brome fractions of the mixtures. Hay vigor was only weakly correlated with total annual yields of the mixtures (r = 0.231). It was concluded that the diverse group of strains was evaluated similarly by the three planting methods if only grass components were considered, but strain differences were concealed by the relatively large contribution of alfalfa to the total yields of the grass-legume mixtures.

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# STRUCTURES OF SOME BRIDGE TYPE COMPOUNDS[1]

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The low temperature, single crystal X-ray study of trimethylaluminum showed that the molecule is a bridge type dimer, the point group symmetry of which is $D_{2h}$:
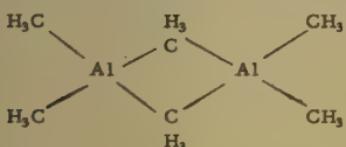


The four methyls external to the four membered ring and the two aluminum atoms are in a plane, the two other methyls being symmetrically placed above and below this plane. The configuration about the aluminum atoms is roughly tetrahedral. This structure is in agreement

with the rule that in 'electron-deficient' bonding the metal atom will tend to utilize all its low energy orbitals. The predictions of Rundle as to molecular shape and dimensions are completely satisfied. The thesis goes on to show that all the following are erroneous: the ethane type structure supported by the electron diffraction study of the gaseous phase, the trimer suggested by Longuet-Higgins involving "protonated" double bonds, and Pitzer's concept of hydrogen bonding. Longuet-Higgins' "methylated" double bond is viewed as nebulous and Gillespie's recent suggestion that the bridge carbon is using d-orbitals in bonding is unreasonable.

The angles within the four membered ring, 70° at the bridge carbon and 110° at the aluminum, are analogous to those found in dimethylberyllium[1] this would suggest that they characterize 'electron-deficient' compounds. The external angle between the two aluminum to nonbridge carbon bonds is quite large, 124°. An explanation for this in terms of the orbital configurations is set forth. The aluminum-carbon distances within the four-membered ring, 2.23 Å, are different from those ex-

1 a. Chairman of Committee, R. E. Rundle, Dept. of Chemistry.
   b. Doctoral Thesis No. 1323. Submitted July 16, 1952.
2 a. A.B. Columbia University, New York, New York, 1947.
      M.A. Ibid., 1948.
   b. Graduate Assistant, Institute of Atomic Research.

ternal to it, $1.99\text{Å}$. The latter is to be compared with $2.03\text{Å}$, the sum of the normal tetrahedral radii. If Pauling's rule is used to calculate bond orders: $R(1) - R(n) = 0.300 \log n$, then the bonds within the ring are of bond order one half.

The aluminum-aluminum distance of $2.55\text{Å}$ <u>versus</u> the $2.52\text{Å}$, which is double the tetrahedral radius of aluminum, suggests metal-metal interaction. This is, however, to be viewed as unlikely; the distance is a consequence of the tendency of the aluminum atoms to achieve maximum orbital overlap with the single bridge carbon orbital. A molecular orbital treatment suggests that there is sufficient binding energy to hold the dimer together without utilizing metal-metal interaction.

Pertinent crystallographic data follow:

$$a_o = 13.0\text{Å}$$
$$b_o = 6.96\text{Å}$$
$$c_o = 14.7\text{Å}$$
$$\beta = 125°$$

The space group has been shown to be unambiguously $C_{2h}^6 - C2/c$. There are four trimethylaluminum dimers per unit cell.

The simple compound, beryllium chloride, offers an opportunity to study halogen bridge bonding. Beryllium chloride is isomorphous with dimethylberyllium and silicon disulfide. The structure consists of continuous chains:
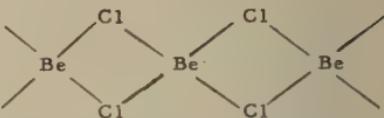


The configuration about the beryllium is essentially tetrahedral. The Cl-Be-Cl bond angle within the four-membered rings is $98.2°$ which is less than the tetrahedral angle, instead of more, as in dimethylberyllium. The closeness of the bond angles in beryllium chloride to those in the covalent compound silicon disulfide would indicate that each beryllium-chlorine bond contains an electron-pair. This is shown to be entirely reasonable by examination of the orbital configuration. Orbital and bond directions are not viewed as coincident. Hence, chlorides isomorphous with 'electron-deficient' metal alkyls are not to be classified as 'electron-deficient' compounds.

Significant crystallographic data are:

$$a_o = 9.86\text{Å}$$
$$b_o = 5.36\text{Å}$$
$$c_o = 5.26\text{Å}$$

There are four $BeCl_2$ molecules per body centered ortho-rhombic unit cell. The space group was established as $D_{2h}^{26}$ -Ibam.

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## METAL CHELATES OF CYCLOHEXENEDIAMINETETRAACETIC ACID[1]

### THOMAS CLEMENT LOOMIS[2]
Department of Chemistry

The sequestering agent ethylenediaminetetraacetic acid (EDTA) has become, in recent years, an important reagent in the field of analytical chemistry. The present work was undertaken to investigate the chelating properties and possible analytical applications of the analogous compound 1, 2-cyclohexenediaminetetraacetic acid (CDTA).

The ionization constants of CDTA at $25.0°C$. and an ionic strength of 0.1 were determined from pH titration curves of

1 a. Chairman of Committee, Charles A. Goetz, Dept. of Chemistry.
  b. Doctoral Thesis No. 1367. Submitted March 11, 1953.
2 a. B.S. Bradley University, Peoria, Illinois, 1948.
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the acid with potassium hydroxide. Similar pH titration curves of CDTA in the presence of a fifteenfold excess of a salt of lead or an alkaline earth metal provided data for the calculation of the stability (association) constants of the complexes formed by CDTA with these metals. These constants were likewise measured at a temperature of $25.0°C$. and an ionic strength of 0.1.

The stability constants of the complexes formed by CDTA with some heavy metals were determined from measurements of the equilibrium constants of reactions involving competition between CDTA and a polyamine complexing agent, triaminotriethylamine, for ions of the heavy metal. These reactions were followed by means of pH measurements made at $25.0°C$. and an ionic strength of 0.1. In order to evaluate these equilibrium constants in terms of the stability constants of the CDTA-

heavy metal complexes, the ionization constants of triaminotriethylamine trihydrochloride and the stability constants of some heavy metal complexes of triaminotriethylamine also had to be determined at 25.0° C. and an ionic strength of 0.1 from pH measurements.

A comparison of the measured stability constants of CDTA chelate complexes with those reported in the literature for corresponding EDTA complexes shows that CDTA forms more stable complexes with nearly all of the metals investigated than does EDTA. The complexing action of CDTA appears to be no less general than that of EDTA. The CDTA complexes studied (in order of increasing stability) were those formed with barium, strontium, magnesium, calcium, manganese (II), lead (II), zinc, cadmium, cobalt (II), copper (II), and nickel (II). The order of magnitude of these stability constants was found to vary from $10^7$ for the barium complex to $10^{24}$ for the nickel complex.

The investigation of the possible analytical applications of CDTA was limited to the study of the complexometric titration of various common metals. The direct titration of copper in ammoniacal solution with CDTA using Murexide (ammonium purpurate) as the indicator was found to yield a very sharp end-point. Similar direct titrations of magnesium and zinc using F241 (Eriochrome Black T) as the indicator also provided highly sensitive end-point indication. Calcium, strontium, lead, zinc, cadmium, manganese, iron, cobalt, and nickel were all titrated indirectly by the addition of an excess of CDTA followed by titration of the excess CDTA with a standard magnesium solution. Due to their lack of specificity, however, all of these

titrations listed above are of practical use only if the metal to be determined has been isolated by a suitable separation procedure.

A method was developed for the separation of lead and copper from complex mixtures by simultaneous electrodeposition from a nitrate-perchlorate-persulfate solution. The copper was determined gravimetrically and the lead was determined volumetrically by the indirect CDTA titration mentioned above. Using this lead and copper determination in conjunction with conventional gravimetric separation procedures, a rapid method for the analysis of tin, lead, copper, iron, nickel, and zinc in brass and other copper-base alloys was devised. The lead, iron, nickel, and zinc determinations were all concluded volumetrically using indirect CDTA titrations. The described method offers the advantage of speed and convenience with no sacrifice in accuracy compared to the usual tedious gravimetric procedures. Results obtained on three typical copper-base alloys are shown.

Standard solutions of CDTA were found to show an appreciable loss in strength during the first few days following preparation of the solution. Thereafter, such solutions did not seriously deteriorate on standing for periods exceeding two months.

End-points obtained in complexometric titrations with CDTA were found to be sharper then those encountered in corresponding EDTA titrations. The titration of magnesium with EDTA was shown to be considerably more affected by variations in the pH of the sample solutions than was the corresponding titration with CDTA. In both of these respects, CDTA appears to be the superior reagent for complexometric titrations.

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## THE REACTIONS OF RADICALS PRODUCED IN THE DECOMPOSITION OF ALIPHATIC AZO COMPOUNDS AND DI-ALKYL PEROXIDES[1]

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Department of Chemistry

In the study of free radicals in solution, those steps which affect the rate of reaction frequently do not influence the nature of the products formed. Thus, in any in-

1 a. Chairman of Committee, George S. Hammond, Dept. of Chemistry.
   b. Doctoral Thesis No. 1352. Submitted December 12, 1952.
2 a. B.S. Tulane University of Louisiana, New Orleans, La., 1948.
   b. Graduate Assistant, Industrial Science Research Institute.

vestigation directed towards elucidating the course of reaction of free radicals in solution, both the rate determining and product determining steps must be considered. The nature of the work herein presented is the investigation of the product determining steps in the decomposition of two types of organic free radical sources, azo-bis-nitriles and tertiary alkyl peroxides. Both are known to cleave, in the rate determining step in the solutions used, by a first order process. The

nature of the products are determined by fast reactions of these radicals which are produced by a unimolecular scission.

Both azo - bis - diethylacetonitrile and azo - bis - dimethylacetonitrile, when decomposed in pure toluene or tetralin, evolve a quantitative amount of nitrogen. The radicals produced, dimethylcyano-methyl and diethylcyanomethyl, will not attack these solvents since no products derived from solvent could be found. However, when a molar amount of chloranil equal to the molar amount of azo-bis-nitrile is present, attack upon solvent occurs and the products in Table 1 are obtained. The structures of all products

### Table 1

Percentage of Products from $R_2C(CN)N = NC(CN)R_2$ in Toluene[a]

| R | Additive | $R_2C(CN)_2$ | $R_2C(CN)OC_6Cl_4OH$ | $R_2C(CN)OC_6Cl_4OC(CN)R_2$ | $C_6H_5OC_6Cl_4OH$ |
|---|---|---|---|---|---|
| $CH_3$ | None | 73 | - - | - - | - - |
| $CH_3$[b] | chloranil | 46 | 2.5 | 27 | - - |
| $CH_3$ | chloranil | 38.5 | 1.9 | 28.7 | 1.7 |
| $C_2H_5$ | none | 73 | - - | - - | - - |
| $C_2H_5$ | chloranil | 31 | - - | 45.3 | 8.0 |
| $C_2H_5$[b] | chloranil | 37 | 6.3 | 44.7 | - - |

[a]Based on one mole of $R_2C(CN)N = NC(CN)R_2$.

[b]Chlorobenzene used as solvent, no toluene present.

were definitely established.

The high percentage yield of dimer is explained on the basis of a "cage effect". The two radicals, produced by the scission of one molecule, collide, not only with solvent but with each other approximately $10^{12} - 10^{14}$ times (1) before diffusing apart. Thus there is a high probability that they may react with each other by dimerization before leaving the immediate vicinity. The high yield of dialkyl ethers of tetrachlorohydroquinone is explained by a "modified cage effect". In this case the two radicals simultaneously react with a third body, chloranil, before diffusion separates them. The mono alkyl ethers of tetrachlorohydroquinone is considered to be produced by radicals which have become kinetically free. The fact that toluene is attacked when chloranil is present but not in its absence is explained by the facile addition of a kinetically free alkyl radical to chloranil followed by a rapid hydrogen atom abstraction from solvent (toluene). A chain reaction is thereby generated.

$$R \cdot + C_6Cl_4O_2 \rightarrow ROC_6Cl_4O \cdot$$

$$ROC_6Cl_4O \cdot + CH_3C_6H_5 \rightarrow ROC_6l_4OH + \cdot CH_2C_6H_5$$

$$C_6H_5CH_2 + C_6Cl_4O_2 \rightarrow C_6H_5CH_2OC_6Cl_4O \cdot$$
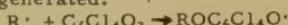
Further evidence for a modified cage effect, or at least three body collissions, being operative in some radical reactions, is shown by the variation in the product yield when two peroxides are decomposed in the presence of each other. The ditertiary alkyl peroxides studied are known to undergo the following reaction in hydrocarbon solvents (2):

$$(CH_3)_3COOC(CH_3)_3 + 2S \rightarrow x(CH_3)_2C = O$$

$$+ y(CH_3)_3COH + S-S$$
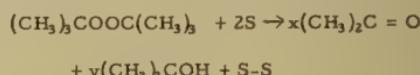
where $x + y = 2$. Kharasch (2) had found that the ratio, $x/y$, varied over a wide range when R was changed in the peroxide, $(CH_3)_3COOCR_3$. Table 2 shows the variation in x when the two peroxides $(CH_3)_3COOC(CH_3)_3$ and ROOR' were mixed.

These data are interpreted to mean that there is a termolecular process occurring which involves two alkoxy radicals and a molecule of solvent. This termolecular reaction can produce either alcohol or ketone but not both and must be in competition with the bimolecular processes. No

Table 2

Percentages of Acetone in Various
Systems at 127.5°

| R | R' | Acetone |
|---|---|---|
| - - | . - - | 16.9-17.7 |
| $(CH_3)_3C^a$ | $(C_6H_5)_3C^a$ | 23.4 |
| $(CH_3)_3C^b$ | $(C_6H_5)_3C^b$ | 20.3 |
| $C_6H_5(CH_3)_2C$ | $C_6H_5(CH_3)_2C^c$ | 20.5 |

[a] Equimolar in ROOR' and
$(CH_3)_3COOC(CH_3)_3$ ·

[b] $[ROOR] = 0.2[(CH_3)_3COOC(CH_3)_3]$

[c] Concentrations such that $k_1[(CH_3)_3COOC(CH_3)_3] = k_2[ROOR]$ ·

suggestion is given as to which product is
produced by this termolecular collision.
The large variation in ketone yield from
the unsymmetrical peroxides (2) compared
to the significant but rather small variation
obtained from mixtures of peroxides sug-
gests that a modified cage effect is opera-
tive and of importance in determining the
products.

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   1950.

# USEFULNESS OF THE HERD AVERAGE
## IN ESTIMATING BREEDING VALUES OF DAIRY CATTLE[1]

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Department of Animal Husbandry

The usefulness of the herd average in
estimating breeding values of dairy cat-
tle where the cows are in a single herd
may differ from the usefulness when ani-
mals from different herds are being
compared. In both instances, however,
the type of use and the usefulness of the
herd average depend on how much of the
differences between averages is genetic
variation.

The material used to study the useful-
ness of the herd average was mainly
from 293 Jersey herds on HIR test from
1943 to 1947. Records of production of
Holstein, Guernsey, and Jersey herds at
Iowa State College from 1938 to 1950
were used briefly. Also, sets of artifi-
cial material formed from tables of nor-
mal deviates were used to clarify some
topics.

An approximate maximum-likelihood

procedure appeared effective for dividing
changes in yearly averages into changes
in average producing ability and changes
in environmental conditions from year to
year. The trends for the Iowa State Col-
lege herds were measured, and the Hol-
stein herd, for example, showed an in-
crease in average ability of 2.4 pounds
of fat per year and an improvement of
average environmental conditions of 2.6
pounds per year. The year to year
changes in the herd averages showed con-
siderable irregularity. The yearly herd
average seemed not to measure the change
in average ability of the herds at all well.

Devices such as "most probable produc-
ing ability" for adjusting cow's produc-
tion records for incomplete repeatability
offer only about 2 per cent to 4 per cent
increase over the lifetime average in ac-
curacy of ranking true producing abilities
or breeding values of cows in the same
herd. The extra labor required to attain
this small increase in accuracy makes
the average of the cow's records gener-
ally more useful to compare animals in
the same herd. "Most probable produc-
ing ability" may be useful if the average
ability of the herd has changed rapidly,
if r is low, if the number of records per
cow varies widely, or if information

about a cow's relatives is being used in an index.

A simple and effective use of the yearly average in a herd is to correct each record for yearly differences in environment, especially if the yearly average of the herd is changing irregularly. This can be done readily by subtracting from each record the herd average for the year in which it was produced. Improvement by selection based on an average of deviations from the yearly averages for each cow may progres as much as 20 per cent faster than that based on single records.

Differences between averages of Jersey HIR herds which exchange bulls were composed of about one-third differences

in average breeding value and about two-thirds differences in average management or environmental conditions. The partitioning of the differences between herd averages was done by analyzing the variance between sisters in different herds. When the ratio of the genetic variation to the total variation is about the same in the differences between herd averages as it is within herds, which it was for the Jersey herds, the herd average has negligible usefulness either negatively to correct for differences in environments of cows in different herds or positively as credit to cows in herds producing higher than the average for the breed.

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## AN APPLICATION OF SEQUENTIAL TESTS TO A PROBLEM OF QUALITY CONTROL[1]

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Department of Statistics

This investigation is concerned with the problem of quality control in situations in which 100 per cent inspection is feasible. The situation is considered in which the production process arises from a stochastic process with a finite set of states.

A particular state is the control state and certain assumptions concerning the probabilities of transitions between states are made. The produced articles are modeled by a sequence of independently distributed random variables. The distribution of the random variable corresponding to the j-th article produced is determined by the state of the production process at the time of production. The random variables corresponding to the production are observed, one at a time, in order. It is assumed that the process is initially in the state of control. The problem is to determine, on the basis of the observed random variables, when the production process has left the state of control. When it is decided that the process is no longer in control, the production process is stopped and returned to the control state.

A cost structure is imposed by considering a penalty cost as a function of the measured characteristic of interest of the produced articles. A fixed cost is incurred when the production process is stopped. A cost is associated with a control procedure by considering the expectation of the present value of the cost incurred if production continues indefinitely.

It is shown that, relative to this model, a cost minimizing control procedure exists and is of a type which is termed recurrent. The idea of a recurrent control procedure is that the decision to stop the production process at any given time depends only upon the variables observed following the immediately preceding time that the process was stopped. In the course of the proof it is shown that the problem may be reduced to a conventional decision problem which considers the behavior of the procedure only until the production is stopped for the first time. The Bayes nature of the cost minimizing control procedure is proved.

Indirect use is made of these results in considering control procedures based on sequential tests. The basic idea underlying this class of control procedure is that of repeating a test until a test is conducted which terminates, with rejection of the hypothesis, that the sequence of observed random variables have the common distribution determined by the control state. For models involving two and three production states, approxima-

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tions of the control procedure cost are given. These approximations are in terms of the sampling characteristics of the underlying sequential tests.

For the special case in which the random variables corresponding to the produced articles have binomial distributions, a modification of the Armitage three alternative sequential test[1] is considered as an underlying test. Approximations to the sampling characteristics of this test are given. These approxima-

tions have the same order of accuracy as the approximations given by Wald for the two alternative probability ratio test.

## REFERENCE

1. Armitage, P. Sequential analysis with more than two alternative hypotheses and its relation to discriminant function analysis. J. Royal Stat. Soc. Ser. B. 12:137-145. 1950.

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## FORECASTING COMPLETION OF THE PRE-ENGINEERING CURRICULUM AT THE UNIVERSITY OF OMAHA[1]

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Department of Vocational Education

The present study was devised to determine the relative importance of various factors related to student achievement, aptitude, and interest in predicting survival of students entering the pre-engineering curriculum at the University of Omaha. Probabilities of survival were computed in such a manner that the student could determine his chances in 100 of successfully completing the pre-engineering curriculum immediately after graduating from high school, after taking the university entrance examinations or, at the latest, after completing the first semester college mathematics.

The 375 students included in the investigation were graduates of Omaha, Nebraska, and Council Bluffs, Iowa, public high schools who entered the pre-engineering

curriculum at the University of Omaha from September 1946 through September 1949. The criterion of survival was a passing mark in second semester calculus. Eighty-six students fell in the survival group and the remaining 289 in the attrition group.

Eighteen variables designed to measure achievement, aptitude, and interest conceivably associated with attrition-survival were available from university records. Biserial correlations were computed to determine which of the eighteen variables would be most valuable in predicting attrition-survival tendency. Eight highly significant correlations were obtained. These correlations with attrition-survival at the three stages of educational progress for which predictions were made were:

| | | |
|---|---|---|
| (1) Upon graduation from high school, | Mean high school mathematics mark | 0.478, |
| | Units of high school mathematics | 0.306; |
| (2) Upon completion of college entrance examinations, | Ohio University Psychological Examination | 0.386, |
| | Cooperative English test | 0.356, |
| | Minnesota test of reading speed | 0.212, |
| | Minnesota test of reading comprehension | 0.323, |
| | Wrenn study habits inventory | 0.213, |
| | Kuder scientific interest | 0.236; |
| (3) Upon completion of first semester college mathematics | First semester college mathematics mark | 0.586. |

Probability tables giving chances in 100 of successfully completing the pre-engineering curriculum were prepared at each of the three stages by means of the discriminant function.

A discriminant function based on the two high school variables yielded a multiple

biserial correlation of 0.498. As mean high school mathematics mark increased from 1.00 to 4.00 and the number of years of high school mathematics experience increased from one to four, chances of survival ranged from 10 in 100 to 40 in 100 predicted from the two-variable combination. A significant loss in predicting efficiency resulted when either of the high school variables was eliminated from the discriminant function. However, since the biserial correlation, based on mean high school mathematics mark alone, was much higher than that obtained from units of high school mathematics and was nearly as great as the biserial correlation from the two-variable equation, a probability table, based only on high school mathematics average, was derived. Here, probabilities of survival ranged from 12 in 100 to 38 in 100 as mean high school mathematics mark increased from 1.00 to 4.00.

In order to predict probability of survival on the basis of the college entrance test battery, a six-variable discriminant function was developed. The multiple biserial correlation corresponding to the six-variable equation was 0.430. No significant loss in forecasting efficiency occurred when cooperative English test score, Minnesota reading speed and comprehension scores, and study habits inventory score were dropped from the prediction scheme. The multiple biserial correlation based on the two remaining prediction variables, Ohio State University Psychological Examination score and Kuder Scientific Interest score, was 0.411. Since the biserial correlation based on the Ohio State University Psychological Examination score was 0.386, almost as great as the multiple biserial correlation obtained from the two-variable discriminant function, two probability tables were prepared for predicting survival from the college entrance test battery.

The probability table based on Ohio State Psychological Examination score and Kuder Scientific Interest score indicated from 6 to 46 chances in 100 of survival as scientific interest score increased from 10 to 100 and the Ohio State Psychological Examination score increased from 10 to 140. A probability table based on Ohio State Psychological Examination score alone yielded chances of survival ranging from 11 in 100 to 43 in 100 as values of the prediction variable increased from 10 to 140.

When the analysis of the college entrance examination battery was concluded, a two-variable discriminant equation was developed using the best prediction variable discovered in each of the first two stages of educational progress. The two-variable combination of mean high school mathematics mark and O.C.A. score yielded a multiple biserial correlation of 0.520 with survival tendency. The probability table based on the two foregoing variables indicated from 8 to 48 chances in 100 of survival as mean high school mathematics mark increased from 1.00 to 4.00 and O.C.A. score increased from 10 to 140.

Probabilities of survival at the end of the third stage of educational progress were developed from two discriminant equations. One prediction was based on first semester college mathematics mark alone. The biserial correlation between this single variable and survival tendency was 0.586, the highest found in the entire investigation based on one variable only. Chances of survival predicted from first semester college mathematics mark ranged from 12 in 100 to 44 in 100 as the mathematics mark increased from failure to A. When mean high school mathematics mark was used in combination with first semester college mathematics mark, the multiple biserial correlation was 0.630. This was the highest correlation found between survival tendency and the various combinations of variables investigated. Chances of survival ranged from 13 in 100 to 49 in 100 as mean high school mathematics mark increased from 1.00 to 4.00 and first semester college mathematics mark increased from failure to A.

According to the evidence presented in the present investigation, the most effective prediction of survival in pre-engineering is available after the student has completed the first semester of college mathematics. Although the prediction of successful completion of the pre-engineering curriculum at the University of Omaha cannot be carried out with more than a reasonable degree of accuracy, it is still possible to give advice, within limitations, to a student concerning his probability of success based on certain evidences of his ability and past achievement.

## EQUIVALENT FUNCTIONS OF STRATEGIES
## IN THE THEORY OF GAMES₁

### HARLAN D. MILLS₂
Department of Mathematics

Consider a zero-sum two-person game with the payoff matrix A, and typical strategy vectors x and y for the two players. Let X and Y be the sets of all mixed strategies of the players, respectively, $X^{*}$ and $Y^{*}$ the sets of optimal strategies, and $\Delta$ the value of the game.

For convenience, let all entries of a vector e, or matrix E, be 1. Matrix operations are understood throughout, and the size of e, or E, is given in context. The intersection of sets U and V is written UV, and the null, or empty, set is 0. Let X' be the set of all x such that $xe = 1$, and Y' the set of all y such that $ey = 1$.

Let U be the set of all u such that $uA = \rho e$ for some $\rho$, $ue = 1$, and V the set of all v such that $Av = \theta e$ for some $\theta$, $ev = 1$. If $U \neq 0$, $V \neq 0$, then $\rho = \theta = uAv$. Conditions that $U \neq 0$, $V \neq 0$ reduce, when A is square, to the condition that the sum of the cofactors of A is not zero.

Let F and G be matrices with constant rows and constant columns, respectively, but otherwise arbitrary. Then, the following results are obtained:

1. Let $U \neq 0$, $V \neq 0$ and $u \in U$, $v \in V$, $B = A + F + G$. Then, for every $x \in X'$, $y \in Y'$,

$xAy = uAv + (x - u) B (y - v)$.

2. Let $XU \neq 0$ and $YV \neq 0$ and $u \in XU$, $v \in YV$. Then, $\Delta = uAv$, $u \in X^{*}$, $v \in Y^{*}$.

The latter result disposes of a certain class of games, including the completely mixed games, insofar as the value and optimal strategy sets are concerned.

Two functionals are suggested by the first result. They are,

$m(x) = \text{Min}_y (x - u) B(y - v)$, $x \in X'$, $y \in Y$,
$n(y) = -\text{Max}_x (x - u) B(y - v)$, $x \in X$, $y \in Y'$,
The following definitions are made:

If $m(x) < 0$ or $n(y) < 0$,
x or y is a point of punishment.
If $m(x) = 0$ or $n(y) = 0$,
x or y is a point of limbo.
If $m(x) > 0$ or $n(y) > 0$,
x or y is a point of reward.

The minus sign in n(y) serves to symmetrize the wishes of the two players, for

the first player will wish to maximize $m(x)$ while the second will wish to maximize $n(y)$. Hence, a single discussion of punishment, limbo, and reward applies equally to either of the players' viewpoints.

Let the set of all points of punishment for either player be P, the set of all points of limbo be L, the set of all points of reward be R. In addition, let the set of all points with punishment not more than $\rho$ be $P(\rho)$, and the set of points with reward not less than $\rho$ be $R(\rho)$, $\rho > 0$ always in either case, $P(\rho)$ a subset of P, etc. Then, the following results are shown with regard to punishment, limbo, and reward.

3. U and V are subsets of L.

4. $m(x)$ or $n(y)$ is a homogeneous functional along a half-ray with origin u or v. That is, if $\gamma > 0$,

$m(u + \gamma (x - u)) = \gamma m(x) = \gamma m(u + (x - u))$,
$n(v + \gamma (y - v)) = \gamma n(y) = \gamma n(v + (y - v))$.

5. $R(\rho)$ is convex. If $XP = X$ or $YP = Y$, $XP(\rho)$ or $YP(\rho)$ is convex.

By means of these results, criteria for playing the game can be easily established. Let a player be required to select a strategy from a closed subset of a half-ray with origin u or v. On a punishment half-ray, the player should select the strategy closest to u or v, on a limbo half-ray, he may select any strategy of the subset, and on a reward half-ray, he should select the strategy farthest from u or v.

It is shown that the set of all points with reward of punishment exactly $\rho$ is the boundary of $R(\rho)$ or $P(\rho)$. Then, if $XR \neq 0$, the best way to play is to select a strategy from the convex set of tangency between X and $R(\rho^{*})$, where $R(\rho^{*})$ contains no point with a neighborhood in X. Similarly, if $XP = X$, the best way to play is to select a strategy from the convex set of tangency between X and $P(\rho^{*})$, where $P(\rho^{*})$ has no interior points of X. Identical criteria hold for the other player.

The use of von Neumann's Main Theorem makes the results below easy to show.

6. $XR \neq 0$ if and only if $YP = Y$.
    $YR \neq 0$ if and only if $XP = X$.
    $XR = 0$ and $YR = 0$ if and only if $XL \neq 0$ and $YL \neq 0$.

Then, by means of these results, and the criteria given above, every game which possesses an expansion is in one and only one of the following classes, and has the value and optimal strategy sets listed below.

7. If $XR \neq 0$, then $X^* = XR(\rho^*)$,
$Y^* = YP(\rho^*)$, $\Delta = uAv + \rho^*$,
If $YR \neq 0$, then $X^* = XP(\rho^*)$,
$Y^* = YR(\rho^*)$, $\Delta = uAv - \rho^*$.
If $XR = 0$ and $YR = 0$, then
$X^* = XL$, $Y^* = YL$, $\Delta = uAv$.

A class, $\top$, of operators, with a typical element, T, is defined which has all games of a given size as its domain. Let the relation $B = TA$, $T \varepsilon \top$, be denoted by B r A. Then, B r A is an equivalence relation. In addition, the operators have the property that $T'TA = T'A$ for arbitrary T and T'. Thus, all games of a given size are divided into equivalence classes. Every element of any class has a pair of invariant spaces, $U^*$ and $V^*$, defined by the sets of all $u^*$ and $v^*$ such that $u^* A = \rho e$ for some $\rho$, $u^* e = 0$, and $Av^* = \theta e$ for some $\theta$, $ev^* = 0$.

A subclass, $\top^*$, of $\top$ is found, such that

if $B = TA$, $T \dot\varepsilon \top$, $U(B) \neq 0$, $V(B) \neq 0$, then $B = T^*A + \gamma E$, $T^*\varepsilon \top$, for some $\gamma$. That is, the class $\top^*$ represents, within a translation of value, every game in any class which possesses an expansion. An invariant for $\top^*$ is that every $T^*A$, $T^*\varepsilon \top$, has the same rank, say r, and for $\top$, every TA, $T \varepsilon \top$, has rank r, r + 1, or r + 2.

Finally, the expansion of an arbitrary element of any class, TA, can be written in terms of the parameters of T, and the invariants of the class to which A belongs, $U^*$ and $V^*$. Then the following property can be deduced from the form of the expansion.

8. Let an arbitrary value, and an arbitrary pair of optimal strategies be given. Then, for every A, there exists a $T \varepsilon \top$ such that TA has the given value and optimal strategies.

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# A PROPORTIONAL COUNTER SPECTROMETER STUDY OF THE BETA-DECAY OF RADIOACTIVE S³⁵, Pm¹⁴⁷, Ni⁶³, and C¹⁴₁

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A proportional counter spectrometer, hereinafter denoted as a p.c.s., of unique design has been constructed for the purpose of measuring beta-spectra whose energies lie below a few hundred Kev. The p.c.s. is well suited for the problem in that thin and uniform radioactive sources which are essential for accurate low energy spectral measurements can be employed. The utilization of radioactive sources of low surface densities is made possible by an allowable source area of a few square centimeters and an ~ 100 per cent geometrical efficiency for particle detection by the p.c.s. In addition, the p.c.s. obviates a Geiger-Muller counter window of finite thickness which is often associated with the magnetic spectrometers. The penetration of beta-particles through the Geiger-Muller counter window can lead to distortion of the beta-spectrum at low energies.

The proportional counter was filled with a 90-10 per cent admixture of argon and methane to a pressure necessary for the complete stopping of all beta-particle in

the counter gas. The resolution of the p.c.s. for electrons of energies above 50 Kev was better than 10 per cent. Energy determination of beta-particles in the range 10 Kev to 200 Kev could be determined to within $\pm 3$ per cent. The spectrometer was calibrated with monoenergetic x-rays and the linearity of the electronic equipment associated with the spectrometer was tested with a mercury relay pulse generator. A total probable error of 4.5 per cent in counting rate at a given energy was induced by counting statistics and electronic fluctuations in the single channel pulse height analyzer of the spectrometer. The upper energy end points of beta-emitters were determined with p.c.s. to within $\pm 2$ per cent of previous magnetic spectrometer measurements. The radioactive source strength required for beta-spectral studies with p.c.s. was less than 10 millimicrocuries.

The beta-spectra of S³⁵ and Pm¹⁴⁷ were measured with the p.c.s. The estimated source surface densities including source mounting material of these two carrier-free activities was approximately 10 $\mu$gm/cm². The upper energy end point determinations were in excellent agreement with previous magnetic measurements on these two nuclides. The data yielded a straight Fermi plot from the upper energy end point

to 10 Kev for $S^{35}$ and from the upper energy end point to 15 Kev for $Pm^{147}$.

The beta-spectra of $C^{14}$ and $Ni^{63}$ were also measured with the p.c.s. A $C^{14}$ source of high specific activity was prepared from $C_7^*H_8O_3$ uniformly labeled. A $Ni^{63}$ source of considerably lower specific activity was prepared from $Ni^*Cl_2$. The estimated average surface densities of these two water soluble sources including source mounting material were: $C^{14}$, 11 $\mu gm/cm^2$ and $Ni^{63}$, 50 $\mu gm/cm^2$. The end point of $Ni^{63}$ was found to be 63 Kev with the Fermi plot concave toward the energy axis below, 30 Kev.

The upper energy end point of $C^{14}$ was found to be in good agreement with previous magnetic measurements, but the Fermi plot of the data was concave toward the energy axis below 50 Kev. The A ' correction (1) for a second forbidden transition with Fermi selection rules tended to straighten the obtained Fermi plot of $C^{14}$.

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## STERIC AND ELECTRONIC INFLUENCES IN ORGANOLITHIUM METALATIONS[1]

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A survey of the history of organolithium metalations showed that little heed has been paid to steric effects in such reactions. Also, with some exceptions, (1) the role of electronic factors in bringing about secondary reactions subsequent to metalation has not been extensively studied.

It was found that 2,4,6-triphenylphenyllithium could be prepared from 2,4,6-triphenylbromobenzene by reaction either with lithium (92 per cent yield) or with n-butyllithium (7 per cent yield). This hindered RLi compound was converted into the corresponding acid by treatment either with Dry Ice (53 per cent yield) or with gaseous carbon dioxide (63 per cent yield).

2,4,6-Triphenylphenyllithium metalated thiophene in the 2-position in 46 per cent yield, p-bromoanisole in the 2-position in 25 per cent yield, dibenzofuran in the 4-position in 4 per cent yield and resorcinol dimethyl ether in the 2-position in 1 per cent yield. Mesityllithium metalated the latter ether in the 2-position in 35 per cent yield. In each case, the yield was determined by the amount of acid formed by carbonation of the reaction mixture. 2,4,6-Triphenylphenyllithium with 6-phenylphenanthridine gave a 2 per cent yield of the same bis-compound which had previously been obtained (2) from mesityllithium and 6-phenylphenanthridine.

Fluorene reacted with various RLi compounds under identical conditions to give, after carbonation, the following % yields of fluorene-9-carboxylic acid: from phenyllithium, 78; from o-tolyllithium, 85; from mesityllithium, 54; from 2,4,6-triphenylphenyllithium, 65. Similarly, triphenylmethane gave the following per cent yields of triphenylacetic acid; from phenyllithium, 6; from o-tolyllithium, 8; from mesityllithium and from 2,4,6-triphenylphenyllithium, none. In the latter two cases, only the acid corresponding to the original RLi compound was isolated.

The reaction of trityl methyl ether with certain RM compounds was studied. The following yields of products were obtained, using in each case two equivalents of the RM compound: from n-butyllithium (mild conditions, followed by hydrolysis), 20 per cent of 9-phenylfluorene; from n-butyllithium (mild conditions, followed by carbonation), 18 per cent of 3,3-diphenylphthalide, from n-butyllithium (forcing conditions, followed by hydrolysis), 4 per cent of 9-phenylfluorene; from phenyllithium (forcing conditions, followed by hydrolysis), 34 per cent of 9-phenylfluorene; from phenyllithium (forcing conditions, followed by carbonation), 13 per cent of 9-phenylfluorene-9-carboxylic acid; from benzylmagnesium chloride, 14 per cent of 1,1,1,2-tetraphenylethane; from t-butylmagnesium chloride, 0.4 per cent of 1,1, 1-triphenyl-2,2,2-trimethylethane; from phenylcalcium iodide, a tar from which only triphenylcarbinol was isolated, but whose infrared absorption spectrum suggested the presence of 9-phenylfluorene. A possible mechanism for the reaction of trityl methyl ether with RLi involves 1)

the metalation of the ether in an ortho-position; 2) attack by the resulting anion on an ortho-position of one of the other phenyl groups, with expulsion of methoxide to form a quinoidal intermediate; 3) removal of a proton from the quinoidal intermediate to yield the 9-phenyl-9-fluorenyl anion.

The reaction of trityl phenyl ether with n-butyllithium gave an unworkable tar. 9-Phenyl-9-fluorenyl methyl ether gave a 10 per cent yield of 9-phenylfluorene when treated with phenyllithium under forcing conditions, and an 8 per cent yield of 9-phenylfluorene when treated with n-butyllithium under mild conditions. Benzopinacol diphenyl ether gave a mixture of unidentified products when treated with phenyllithium under forcing conditions.

Benzothiazole with n-butylmagnesium bromide at room temperature gave, after carbonation, 3 per cent of a product tentatively identified as benzothiazole-2-carboxylic acid. The same reaction at 0° gave a 2 per cent yield of bis-2-benzothiazolyl, but no acid.

Phenylcalcium iodide reacted with triphenylamine to give, after carbonation, a small amount of impure acidic material which was not identified. Phenylcalcium iodide failed to metalate dibenzothiophene-5-dioxide at -30°. n-Butylmagnesium bromide reduced this dioxide to dibenzothiophene; the yield was 2 per cent at room temperature and 15 per cent at 100°.

Phenyllithium metalated 9-phenylfluorene to give an 80 per cent yield of 9-phenylfluorene-9-carboxylic acid. Lithium aluminum hydride was without effect on fluor-

ene when the mixture was heated in ether or in ether-benzene.

2-Methoxynaphthalene reacted with mercuric nitrate at room temperature to give 48 per cent of 2-methoxy-1-naphthylmercuric nitrate, which melted at 143-146° with decomposition after extraction with water and with ether. This compound reacted with bromine to give an 8 per cent yield of 1-bromo-2-methoxynaphthalene, and with iodine to give a 94 per cent yield of 1-iodo-2-methoxynaphthalene. The reaction of 2-methoxynaphthalene with mercuric nitrate at 100° yielded a tarry oxidation product which was not identified. Attempts to mercurate 2-methoxynaphthalene with mercuric bisulfate yielded no well-defined product. Similar failures were encountered in the reaction of dibenzothiophene with mercuric nitrate and with mercuric bisulfate.

Indium chloride failed to react with refluxing thiophene.

Methyl o-iodobenzoate was prepared in 70 per cent yield from sodium o-iodobenzoate and dimethyl sulfate. An attempt to prepare 2-iodophenyldiphenylcarbinol from this ester by treatment with phenylmagnesium bromide yielded a tar which could not be purified.

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## ECOLOGY OF NATIVE PRAIRIE IN IOWA[1]

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From the few scattered tracts of prairie which still persist as parts of undivided estates, the State Conservation Commission has purchased two quarter-section prairie reserves: The Hayden prairie,

located in northeastern Iowa, in 1945, and the Kalsow prairie, located in northwestern Iowa, in 1948.

An ecological investigation of these two native prairie tracts was begun with an inventory which included the taxonomic identity, floristic composition, stability of prairie, distribution of species, forage yield, amount of mulch and roots, and soil structure. On this basis it becomes possible to characterize each area and prescribe management practices most likely to be successful in maintaining the prairie in its native condition.

Prairie is characterized by the abundant

and dominant grasses which constitute the prevailing life form. Intermingled with the grasses is a great variety of forbs. This floristic complex of grasses and forbs can be described more simply and clearly through the use of the plant family as a unit than by an enumeration of species. A total of 149 plant species representing 106 genera in 35 families was found on the Kalsow prairie. The 134 species of plants on the Hayden prairie were distributed in 99 genera and 36 families. On the Kalsow area 20 families included 90 per cent of the species in the flora. The remaining 10 per cent of the flora included 15 families, each represented by only one species. On the Hayden tract the 17 largest families included more than 86 per cent of the total number of species, and 19 other families made up the remaining 14 per cent. Over 50 per cent of the species of the two prairies were included in the three largest families, Compositae, Gramineae and Leguminosae. About 40 per cent of them were in either Compositae or Gramineae.

Stability of prairie vegetation was shown by its resistance to invasion by weedy plants from the surrounding cultural vegetation.

The frequency percentages of the species encountered in the quadrat survey of the two prairies were tested by Raunkiaer's law of frequency. The percentage of species in the frequency classes agreed rather well with the "normals" of Raunkiaer and Kenoyer, especially with that of Kenoyer.

The distribution of plant families in the various frequency classes on the Hayden prairie tapered from 16 in Class A to 8 in Class B, 5 in Class C (Gramineae, Compositae, Leguminosae, Umbelliferae, and Santalaceae), 2 in Class D (Gramineae and Compositae), and 1 in Class E (Gramineae). On the Kalsow prairie, Class A had 20 families, Class B, 5 families, Class C, 5 families, Class D, 3 families (Gramineae,

Compositae and Umbelliferae), and Class E, 1 family (Gramineae).

Percentage composition by weight was determined for species on the basis of weight-estimate percentage and frequency percentage. The three families of Gramineae, Compositae and Leguminosae furnished over 90 per cent of the percentage composition of each prairie. Gramineae, alone, made up over 80 per cent of the forage by weight.

Plants found in the weight-list quadrats were arbitrarily classed into dominant, principal and secondary groups based on the contribution of each species to the forage yield.

Forage and mulch yields were higher on the Hayden than on the Kalsow prairie. There was no difference between the two prairies in the amount of roots in the upper 18 inches of soil.

An evaluation of the physical condition of the soil profile under prairie and cultivated lands included a determination of volume weight, porosity and aggregation. The two prairies did not differ significantly with respect to these indices of soil structure. The soil in both prairies was superior in structure to that in adjacent cultivated fields. Aeration porosity and aggregation were higher and volume weights lower than in the cultivated fields.

There seemed to be a direct relationship between the quantity of roots and the percentage of water-stable aggregates greater than 2 mm in the 0-6 and 6-12 inch soil levels of both prairies. On the Kalsow prairie the linear root-aggregate relationship was highly significant in the 0-6 inch soil depth and significant in the 6-12 inch depth. On the Hayden tract the relationship was highly significant in the upper 6 inches of soil, but not significant in the 6-12 inch level of soil.

PROPERTIES AND DISTRIBUTION OF CASEIN AND
NON-CASEIN PROTEINS, CALCIUM AND PHOSPHORUS IN
SKIMMILK, BUTTERMILK AND BUTTERSERUM FROM THE SAME WHOLE MILK[1]

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It was intended originally to employ the Ling (1936) titration procedure as a means of evaluating the "true serum acidity" (that is, the acidity resulting from non-casein components) in skimmilk, buttermilk and butterserum (the aqueous phase of butter). Ling's procedure involves titration of oxalated and non-oxalated samples of milk and its rennet whey. Early in the investigation it became apparent, however, that butterserum, even from unsalted butter, did not yield a normal coagulum with rennet and that buttermilk frequently formed a weak coagulum.

These findings prompted the present study the objectives of which were (1) to determine the reason for the inability of casein in some of these products to coagulate with rennet, (2) to determine whether a study of the protein fractions in skimmilk, buttermilk and butterserum from a single milk source would throw further light on the adsorbed materials in the fat globule-serum interphase, (3) to determine whether differences could be shown among the casein and non-casein protein preparations from skimmilk, buttermilk and butterserum from a single milk source, (4) to determine the distribution of calcium, phosphorus and the common protein fractions in these products and (5) to obtain, if possible, further information with regard to the mechanism of the reaction between rennet and casein.

Incomplete Ling titrations and titrations of the sera resulting from alcohol-acetone (7:3) precipitation of the proteins in skimmilk, buttermilk and butterserum suggested that the calcium phosphate-caseinate complex in buttermilk and butterserum is less completely formed than in skimmilk.

Calcium and phosphorus analyses also suggested less complete formation of calcium phosphate-caseinate complexes in butterserum than in skimmilk because the calcium and inorganic phosphorus contents of the butterserum were only 50 to 60 per cent of those in the corresponding skimmilks. The lipid phosphorus contents of

buttersera, on the other hand, were 5 to 25 times higher than in the corresponding skimmilks and buttermilks.

On the basis of fat-free products, the total protein and casein contents of skimmilk and buttermilk were practically alike while total protein and casein contents of butterserum were only 81.6 and 84.8 per cent of that in skimmilk. On a fat-free solids basis, total protein and casein contents in skimmilk and buttermilk were also alike while in butterserum they were 110.8 and 113.9 per cent, respectively, of that of skimmilk.

On both the fat-free product and the fat-free solids basis, the albumin contents of buttermilk and butterserum were 110 and 29 per cent, respectively, of that of skimmilk. The proteose-peptone and globulin fractions showed no significant variations among the products although the former tended to be lowest in buttermilk and the latter highest in butterserum.

The hypothesis is offered that albumin, as one of the labile components of the fat globule-stabilizing material in milk and cream, is removed from the fat globule-serum interphase during churning and released in the buttermilk. The low albumin content of butterserum, in itself, offers no explanation of the non-coagulability of butterserum unless it be assumed that colloidal calcium phosphate, adsorbed on the albumin, is removed simultaneously. Current rennet coagulation theories include the concept of di- or tricalcium phosphate associated with casein as a prerequisite to coagulum formation.

Casein and whey proteins prepared from skimmilk yielded transparent suspensions in veronal-citrate and phosphate buffers. Casein and whey proteins prepared from buttermilk and butterserum yielded turbid suspensions suggesting the presence of lipid material. Attempts were made to remove the lipids from the protein preparations by a procedure used by Blix (1941) for removing lipids from blood sera. In this procedure the protein material was extracted at -23°C. twice with acetone, once with a mixture of acetone and ether (2:1) and twice with ether.

Insignificant quantities of lipid material were found in the ether extracts of skimmilk and buttermilk casein and of the skimmilk whey proteins. The ether extracts of

two buttermilk whey protein preparations contained lipid material to the extent of 2.0 and 3.7 per cent, respectively, of the original preparations. The lipid residues from two butterserum caseins were 6.7 and 9.3 per cent, respectively, of the original protein. The lipid residues recovered from the ether extracts of several preparations of butterserum whey protein were from 14.0 to 25.0 per cent of the original weight of protein.

In general, the lipid residues from the ether extractions of water suspensions of the proteins contained little or no phosphorus while residues resulting from extraction of two whey protein preparations in phosphate buffer contained 1.74 and 4.00 per cent phosphorus.

The phosphorus content of buttermilk casein was slightly lower than that of skimmilk casein. The P/N ratios in extracted skimmilk and buttermilk caseins were 0.049 and 0.046, respectively. Extracted butterserum casein contained 11.71 per cent nitrogen (compared with 14.27 and 14.31 per cent in skimmilk and buttermilk casein, respectively). The phosphorus content of butterserum casein increased from 0.73 to 0.92 per cent as a result of acetone-ether extraction, and the P/N ratio increased from 0.067 to 0.079.

The phosphorus contents of two non-extracted skimmilk whey proteins were 0.39 and 0.40 per cent. Extraction with acetone and ether did not change this value. The phosphorus contents of two buttermilk whey proteins were 0.45 and 0.58 per cent. The latter value increased to 0.65 per cent after extraction. Two unextracted butterserum whey protein preparations contained 1.75 and 1.15 per cent phosphorus. The latter value increased to 1.75 per cent as a result of extraction.

The high lipid phosphorus content of butterserum itself and the high total phosphorus content of the casein and whey proteins prepared from butterserum indicated the presence of phospholipid-protein complexes in this product. Assuming that complexes are formed, those with whey proteins contain larger amounts of phospholipids than the complexes formed with casein. Extraction with acetone and ether at -23°C. did not remove phospholipids from such complexes as exist. It is believed that the lipid material removed with acetone-ether extraction consists mostly of small or submicroscopic fat globules which are held in suspension by the hydra-

ted proteins.

Electrophoretic patterns of extracted and non-extracted buttermilk and butterserum caseins in veronal-citrate buffer at pH 8.45 gave evidence of components which were not apparent in skimmilk casein. The α-fraction in extracted butterserum showed a tendency to resolve in two separate components; the peak area of the major α-component was smaller than that of the α-component in skimmilk and buttermilk casein and had lower mobility.

Electrophoretic patterns of skimmilk whey proteins in phosphate buffer at pH 7.7 indicated the presence of six or seven components. The components of buttermilk whey protein did not resolve as well as those of skimmilk whey protein. Butterserum whey protein yielded incomplete patterns because of an opacity which seemed to be associated with the major component. It is possible that non-coagulation of butterserum with rennet is due to changes in the -fraction of its casein or to changes in the α:(β+γ) ratio. If phospholipid-casein complexes are formed, it may be that certain groups in the casein molecule, which are normally involved in the rennet reaction, are not available for this type of reaction. Emphasis is placed on the involvement of the α-fraction because Nitschmann and Lehmann (1947), Gonashvili (1949) and Kerns (1951) have presented evidence to the effect that the α-casein fraction is the one primarily involved in rennet coagulation.

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# LIGHT SCATTERING BY TOBACCO MOSAIC VIRUS NUCLEIC ACID₁

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The molecular weight of ribonucleic acid (RNA) from tobacco mosaic virus (TMV) has been measured by the technique of light scattering. The scattering instrument measured the intensity of scattered light at all angles from 20° to 155° with respect to the direction of incident light. The 4358 Å line from an AH-4 mercury arc lamp was the source of light.

The scattering instrument was calibrated with colloidal silica solutions. Both the turbidity of these "Ludox" solutions and the scattering by them was determined as a function of concentration. To obtain the calibration constant, the ratio of turbidity to scattering was extrapolated to zero concentration so as to eliminate particle interaction and multiple scattering effects.

A differential refractometer which employed an optical lever principle was used to obtain the refractive increment of the RNA solutions, a quantity needed to convert light scattering data to a molecular weight. The refractometer was calibrated with KCl and NaCl solutions of known index of refraction. The refractive increment of the RNA was found to be 0.194 ml-gm⁻¹.

The RNA was separated from the TMV by heating a virus solution in boiling water for times ranging from 60 seconds to 5 minutes. This treatment coagulated the protein, which was then centrifuged off. The RNA, which remained in the supernatant, was cleaned of dust by filtration through Corning "ultrafine" porosity filters. These filters, which were cleaned in concentrated HNO₃, had to be neutralized by soaking for 24 hours in 1 N NaOH. Filters not so neutralized caused degradation of the RNA.

It was found that the RNA prepared by this heat method disintegrated rapidly at room temperature. The disintegration could be halted by cooling the RNA to 2°C. Since the molecular weight of undisinte-

grated RNA increased slightly as the preparative heating time was increased from 60 seconds to 5 minutes, the observed disintegration at room temperature could not have been solely a thermal collision process, but must have been enzymatic. Several attempts were made to remove or poison the enzyme. No completely effective method was found. However, after extraction of the RNA solution with chloroform-octyl alcohol, the decrease in molecular weight was about 25 per cent, in place of the 80 per cent or more which occurred with unextracted RNA. The source of the enzyme was not definitely established. The experimental evidence indicated that it was a part of the virus, rather than a contaminant in the original virus preparation.

The "extrapolation" method of obtaining molecular weights from scattering data was used. This method gives a molecular weight which is not based on any assumption concerning the molecular shape. Correction for anisotropy of polarizability of the RNA molecules was made at all angles. It was found that this correction was of sufficient magnitude that its omission would cause serious error in determining molecular shape from the angular distribution of scattered light. However, a shorter wavelength than 4358 Å would be needed to learn the shape of the RNA molecule.

The molecular weight of the RNA corresponded to the weight of all the RNA in a virus rod. For by means of phosphorus analyses the TMV was found to contain 5.6 $+$ 0.5 per cent RNA by weight. The light-scattering molecular weight of the TMV was $40.0 \times 10^6$ and the molecular weights of twelve RNA preparations ranged from $1.87 \times 10^6$ to $2.25 \times 10^6$ for preparative heating times in the range of 60 seconds to 2 minutes. The higher weights seemed to go with the longer heating times. Heating for 5 minutes gave a weight of $2.70 \times 10^6$, perhaps as a result of aggregation during prolonged heating.

Since all of the RNA was removed in one piece, it is likely that the RNA is contiguous in the TMV rod, rather than scattered in discrete sites.

## ECONOMICS OF FORAGE PRODUCTION AND UTILIZATION IN DAKOTA AND DIXON COUNTIES, NEBRASKA[1]

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The objectives of this study were to es-
timate, on a specified population of farms:
1. The economically optimum combina-
tions of forage and grain under alter-
native soil management systems.
2. The relative profitability of alternative
livestock systems for the utilization of
the feed produced under alternative
soil management systems.

Empirical data were secured from a
random sample of 30 farms in the east
loess hills region of northeast Nebraska.
The sample was drawn from a population
of farms which were restricted to 160 acres
to Moody-Crofton soils, and by certain
topographical limitations. Several tests
were made to determine the homogeneity
of the sample with respect to certain fac-
tors which might have influenced the re-
sults. The analytical procedure consisted
of two major steps: (1) a descriptive anal-
ysis by means of regressions and tabular
comparisons; (2) a budget analysis of al-
ternative systems of soil management and
feed utilization. The proportion of forage
acreage in the cropping system (called the
forage index) was used as the independent
variable in these analyses.

A highly significant relationship was
found between the yields of corn and the
forage index. Such a relationship results
from (1) the direct effect of legumes in the
rotation and (2) the indirect effect of man-
ure. The amount of manure hauled per
year was directly associated with the for-
age index on the sample farms. Despite
fewer acres of grain in 1950, the high-
forage farms produced more feed units of
grain than the low-forage farms. The re-
lationship between the total feed produc-
tion and forage index was curvilinear;
within a proportion of 35 per cent of for-
age acreage in the rotation the feed pro-
duction was positively related to the for-
age index; in the higher range of forage
index the relationship was negative.

Farms with low acreages of rotated for-

age tended to sell more grain for cash.
High-forage farms had higher investments
in milk cows and other forage-consuming
livestock and bought some additional hay.
The low-forage farms raised more hogs
and fattened more feeder cattle in drylot.
High-forage farms had larger volumes of
business as well as larger net incomes
than those in the low-forage range. These
differences were not statistically signifi-
cant, however, due to the wide variance
of the data.

The first phase of the budget analysis
involved the estimation, on the basis of
detailed yield estimates, of the types and
quantity of feed which could be produced
on the sample farms with the adoption of
each of the following alternative soil man-
agement systems. (a) control of erosion
by the use of rotations only; (b) rotations
with contouring and terraces to control
erosion; and (c) rotations with contouring,
terraces, and fertilizers. Rotations were
selected for the alternative soil manage-
ment systems under the criteria of (1) an-
nual soil loss per acre and (2) the rela-
tive prices for crops.

Under a soil management system which
would control erosion by rotations alone,
the acreage of grain would be limited.
The rotation $CO_g$ could be used on Judson
silt loam, while COMM to COMMMM
combinations could be used on Moody soils
of less than 10 per cent in slope. The
steeper Moody soils, as well as the Crof-
tons, would have to be left under grass
continuously, except for reseeding. Where
contouring and terraces are a part of the
soil management system, more grain could
be raised. $CCO_g$ would be most profitable
on Judson soils; $CO_g$ or $CCO_g$ would maxi-
mize gross value on Moody soils of less
than 10 per cent slope. On the steeper
Moody soils and the Croftons, rotations of
COMM to COMMMM would maximize gross
returns within the limit of erosion control.

The production of feed would average
432 units (corn equivalents) less per farm
under a soil management system of rota-
tions alone than under present systems on
the sample farms. The second alterna-
tive soil management system would in-
crease the annual feed unit production to
4022, or 125 in excess of the present sys-
tem. The application of fertilizer would
yield a further increase of 1260 feed units.
Analyses were made of nine alternative

systems of feed utilization in conjunction with the first and third soil management systems. These livestock systems were dairy cows, beef cows, three calf and three yearling steer feeding systems, and a two-year feeding system. Under each system the cattle would use the forage; hogs would use any remaining grain.

The capital requirements for livestock would be higher under a "rotation only" soil management system than under one including the mechanical practices and fertilizer. Also, the capital requirements for the feeding systems would exceed those for the dairy or beef cow systems.

Higher net income would result from livestock used with a soil management system of rotations, terraces, contouring, and fertilizers than one of rotations alone. The beef cow and feeding systems would be most profitable under 1950 prices; under 1938-1944 prices, dairy products were relatively higher, and consequently dairy cows would be more profitable.

With a soil management system of rotations, contouring, terraces, and fertilizers, the net incomes from all livestock systems would exceed those of the present systems on the sample farms. However, losses would result from several livestock systems used with the soil management systems of rotations only; this would be especially true under 1939-1944 prices.

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## DIFFUSION IN ALPHA BRASS[1]

FELIX S. PALUBINSKAS[2]
Department of Physics

The present investigation was undertaken for the purpose of determining the diffusion coefficients of radioactive zinc in copper and alpha brass single crystals at selected high temperatures. To carry out this program the author designed and constructed various pieces of equipment for the operations required in the investigation.

A Bridgman furnace was built for growing single crystals. Approximately half of the runs with this furnace were successful in producing large single crystals of alpha brass. In the remainder of the runs either biocrystals or very coarse-grained polycrystals were produced.

Single crystals of copper and alpha brass were sectioned into wafers, polished, coated with radioactive zinc, sealed off in evacuated vycor tubes and allowed to diffuse in a high temperature furnace for a certain time.

The furnaces used for the diffusion anneal were of novel design. Two separate windings, one over the other, were used as the heating elements. In one of the windings the current was always on; in the other the current was alternately on and off according to the demands sensed

by the temperature controller.

Two types of temperature controllers were used: a commercial thermocouple-actuated controller and a platinum resistance thermometer-actuated controller. These served to maintain the temperature within the furnaces constant to within $+1°C$. The platinum resistance-actuated controllers were not used above $900°C$. as conductivity difficulties were encountered in the ceramic furnace components which resulted in a loss of temperature control.

The diffusion of zinc into single crystals of copper in the temperature range from 600 to $1000°C$. was found to obey the following Arrhenius equation:

$$D = 0.067 \ e^{\dfrac{-42,100}{RT}}$$

An Arrhenius equation of the same form was found to represent the diffusion of radioactive zinc into single crystals of 13.2 atomic per cent Zn alpha brass in the temperature range from 600 to $850°C$. It was found to be

$$D = 0.18 \ e^{\dfrac{-41,600}{RT}}$$

Reasonable agreement has been found between the value of $D_O$ obtained in this investigation and that calculated from Zener's $D_O$ theory. Close agreement has been found with Dienes' proposed equation for $D_O$, thus giving his empirical correlation added significance.

On the basis of Seitz and Huntington's

calculations of the energy required by various mechanisms for obtaining self-diffusion in copper, it is concluded that the mechanism for the diffusion of radio-active zinc in copper single crystals is probably a vacancy mechanism.

## ABSORPTION SPECTRUM OF THULIUM SULPHATE OCTAHYDRATE[1]

ARTHUR PASKIN[2]
Department of Physics

An investigation was carried out to see if the term splitting of thulium sulphate octahydrate could be understood in terms of crystal field effects.

The effect of the crystal potential on the energy levels was calculated according to first order perturbation theory. It was assumed that the local point symmetry for thulium sulphate is $D_{3h}$. For ease of calculation, the crystal potential was expanded in terms of spherical harmonics $Y_\ell^m$. The appropriate matrices were evaluated by group theoretical methods. From these matrices the energies of splitting were found in terms of four parameters which involve mean radii and crystal fields. The mean radii were approximated with the aid of screened hydrogenic wave functions. The crystal fields were determined from present knowledge of the local structure of the rare-earth sulphate octahydrates. Unfortunately, present data only allowed the field contributions to be calculated for nearest neighbor contributions. In these calculations the oxygen ions were treated as point charges.

Matrix calculations were modified to take into account departures from Russell-Saunders coupling and the term splittings then found in terms of these modified matrices and the estimated values of the four parameters. It was found that only the parameter involving the $Y_2^o$ field term was important in thulium.

In order to calculate an absorption spectrum it is not only necessary to know the relative position of the energy levels but also the transition mechanism and hence the appropriate selection rules. If it is assumed that the $4f^n$ configuration is the only important configuration for the rare-earth ions studied, then the most important transition mechanisms are magnetic dipole and electric quadrupole. The intensity and selection rules for these two transition mechanisms were calculated. These calculations were first made neglecting crystal coupling effects and then with the coupling effects included. It was found that the crystal coupling effects were important and that transitions induced by these effects were often more important than transition processes calculated neglecting crystal coupling. Thus, electric quadrupole transitions were found to be less likely than either direct or induced magnetic dipole transitions and the latter in turn were found less likely than crystal induced electric dipole transitions. The most likely process of all was found to be the direct magnetic dipole transition.

Zeeman patterns were also studied for the several interesting directions of propagation and polarization of the light relative to the magnetic field direction. It was found that these patterns may be of some use in the identification of levels, which in turn should allow an empirical determination of the four parameters which are necessary for crystal splitting calculations.

For further study of the crystal fields, calculations were made of the magnetic susceptibility of thulium. Susceptibility calculations were also made for praseodymium and neodymium sulphate octahydrate. Comparison of theoretical and experimental data for the latter salts indicated that the sign of the $Y_2^o$ field term is in error. This error is attributed to the nearest neighbor approximation used in field calculations.

1 a. Chairman of Committee, Joseph M. Keller, Dept. of Physics.
   b. Doctoral Thesis No. 1353. Submitted December 22, 1952.
2 a. B.S. South Dakota School of Mines and Technology, Rapid City, S. Dak., 1948.
   b. Research Assistant, Institute of Atomic Research.

## ADSORPTION BY A CUPROUS OXIDE CATALYST₁

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Department of Chemistry

A review of the literature on the subject of catalytic hydrogenation reveals the fact that, in favorable cases, a study of the adsorptive capacity of the catalyst for the reactants and products of the hydrogenation reaction can lead to an elucidation of (a) the mechanism of the reaction and (b) the role of the catalyst.

Previous work by Menzel (1), Stewart (2), Lefrancois (3) and Stanerson (4) had shown that cuprous oxide, promoted by calcium oxide and stabilized by vanadium tetroxide, is an active catalyst for the hydrogenation of furfural to furfuryl alcohol. Stanerson had investigated the adsorptive capacity of the catalyst for hydrogen.

Some of Stanerson's work was repeated and it was found that the adsorption of hydrogen did not begin at 60°C. and was not rapid at 100° as Stanerson had reported. Instead, adsorption proceeded slowly at 100°. It was shown that preheating the catalyst to constant weight at 190° had no particular effect on the adsorptive capacity of the catalyst, whereas the rate of adsorption was much slower on the pre-heated catalyst than on an unheated sample. The volume of hydrogen adsorbed was enormous compared to that found by Stanerson.

The irreversibility of the adsorption of hydrogen, as reported by Stanerson, was confirmed, but it was found that the adsorption was also complicated by reduction of cuprous oxide to copper.

The adsorptive capacities of the catalyst for furfural and furfuryl alcohol were also investigated. It was found that the catalyst would not adsorb furfural at temperatures below 190°C. At this temperature, adsorption did occur, but it was immediately followed by reaction, since no furfural could be recovered from the catalyst. It was shown that the furfural was not converted to either furoin or furil.

In the case of furfuryl alcohol, it was found that irreversible adsorption occurred at temperatures as low as 75° and that most of the furfuryl alcohol was converted to some compound which does not contain an hydroxyl group.

Thus, it may be concluded that the mechanism of the liquid phase hydrogenation of furfural to furfuryl alcohol in the presence of a cuprous oxide catalyst involves the chemisorption of hydrogen, followed by reaction with molecular, unadsorbed furfural to form unadsorbed furfuryl alcohol.

Attempts to prepare pure cuprous oxide by the reduction of cupric nitrate solutions by means of a mild inorganic reducing agent in both water and methanol media failed to yield a preparation free from copper and cupric oxide.

Attempts to prepare pure vanadium tetroxide by the reduction of pervanadyl sulfate solutions failed to yield a preparation free from vanadium pentoxide, even though precautions were taken to assure complete reduction of the vanadium to the tetravalent state before precipitation, and contact with air was avoided during all the filtering, washing, and drying steps.

### REFERENCES

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2. Stewart, M.M. Some metallic oxides as promoters for copper oxide catalysts in the hydrogenation of furfural. Unpub. Ph.D. Thesis. Iowa State College Library, Ames, Iowa. 1940.
3. Lefrancois, P.A. Cuprous oxide as a catalyst: The effect of varying the proportion of promoter and stabilizer. Unpub. Ph.D. Thesis. Iowa State College Library, Ames, Iowa. 1944.
4. Stanerson, B.R. A correlation between adsorption of hydrogen and activity of some catalysts containing oxides of copper. Unpub. Ph.D. Thesis, Iowa State College Library, Ames, Iowa. 1939.

## INFLUENCE OF ENROLLMENT AND EXPENDITURES UPON QUALITY OF EDUCATION IN IOWA SCHOOL DISTRICTS MAINTAINING HIGH SCHOOLS[1]

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Department of Vocational Education

Since 1900, expenditures for public education in the United States have increased from 215 million dollars to 4,311 million dollars in 1948. Much of this increased expenditure is attributable to the fact that schools are educating more pupils, the number enrolled having increased from 15.5 million pupils in 1900 to over 23.9 million pupils in 1948. A considerable portion of the increased expenditures was attributable also to more services provided by the public schools and a decline in the purchasing power of money. At the same time there has been a growing criticism of the property tax as the major source of school revenue and accompanying demands for state financing of education. The states in turn have insisted on more efficient expenditure of school funds through more adequately organized local school districts. Like other states, Iowa has been a part of this broad movement. It was important, therefore, to determine the relationships between the size of schools, the cost of education, and the quality of education among the school districts of Iowa.

The purpose of this study was to determine the relative influence of both size of school and cost of education in determining quality of education in the school districts of Iowa which maintain high schools. The study was primarily concerned with the following specific questions:

1. What is the relationship (a) between size and quality, (b) between cost and quality, and (c) between size and cost?

2. What is the relative influence of both size and cost upon quality?

A review was made of previous studies relating to the problem to determine the status of studies on the size-cost-quality relationship. It was found, in school systems considerably larger than the average in Iowa, that, as the size of the school increased, the quantity, and also the quality, of the educational program

improved; that as the size of the school increased, the per pupil cost declined; that increases in expenditures generally produced an improved quality of education; and, finally, that the size of a secondary school may have a greater effect upon the quality of education than per pupil cost differences if the school is smaller than 500 pupils. It was questionable, however, whether these results were applicable to the schools of Iowa, varying as they do from extremely small, obviously inefficient schools to large well-ordered school systems.

The study was confined to the high schools, grades 9 through 12, of those 831 Iowa school districts which maintained four-year approved high schools in 1950-1951. The data used in the study were secured from the official records in the Iowa Department of Public Instruction.

The quantitative measure developed for determining the quality of education was the "unit of educational opportunity", this being defined as one subject counting toward graduation carried by a student for one year. The quality of educational opportunity provided in the individual school districts was the total number of units of educational opportunity, and/or the score received by each respective school district on a community school criteria check list, consisting of 100 items. Per pupil cost was the cost per pupil in average daily attendance in high school, and size of school was based upon the total average daily attendance in high school.

The investigation revealed the following relationships between the size, the cost per pupil, and the quality of education in the 831 Iowa school districts maintaining high schools in 1950-51.

1. The size of school had a positive relationship to the quality of educational opportunity. As the size of the school increased, the average number of units of educational opportunity also increased.

2. There was a higher degree of relationship between community school score and number of units of educational opportunity than between community school score and size of school.

3. Schools with richer programs were more likely to approach the community school ideal than schools with poorer programs.

4. As the cost per pupil increased, the average number of units of educational opportunity decreased, except for a very few schools on the lower range of the expenditure scale. These findings are not necessarily inconsistent with the findings of other studies which have shown that educational opportunities increased as expenditures increased since these studies have not generally included small schools, or schools that varied widely in size, as does the present investigation.

5. There was an inverse relationship between size of school and cost per pupil; as the size of the school increased, the per pupil costs declined.

6. As the size of the school increased, the average cost per pupil per unit of educational opportunity decreased.

7. The average cost per pupil per unit of educational opportunity in school districts having the lowest average daily attendance was between four and five times as large as that of the largest school districts.

8. Although size of school and commu-nity school score were both reliable predictors of quality of education, the former was 30 times as important as the latter.

9. Although size of school and cost per pupil were both reliable predictors of quality of education, the former was 7 times as important as the latter.

10. In most of these relationships there were only minor differences between consolidated school districts and independent town and city school districts, the relationships generally holding true for either or for both together.

The general conclusion is that size of school was a more important determinant of the quality of education in the 831 Iowa high schools than was educational cost. While this conclusion might imply that, in terms of state policy, the state might spend considerably more effort in reorganizing its school districts, such an implication should not be drawn until a similar study of these relationships among elementary schools has been made.

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## USE OF AND DEMAND FOR ELECTRICITY IN SIXTEEN FARM HOMES IN MARSHALL AND JASPER COUNTIES, 1950-1951[1]

MABEL KATHRYN PHILSON[2]
Department of Household Equipment

A field project on demand and diversity of use of electricity on sixteen farms in the eastern livestock area of Iowa was carried out by the Agricultural Research Administration of the United States Department of Agriculture in cooperation with the Iowa Agricultural Experiment Station. The following data were obtained:

1. Records of the electric current used on the 16 farms, in eight of the farm homes and by ranges used in the homes.

2. Records of the voltage of the whole farm.

3. Tabulations of descriptive information on families, house facilities, and household electric equipment.

4. Information on use of household electric equipment.

The original project, planned primarily for the use of rural power suppliers, did not fully exploit the data related to use and demand of household electric appliances: this study further develops the data on household appliances, especially the data on ranges, refrigerators, freezers, laundry equipment, water heaters, and vacuum cleaners.

The farms were so selected that four had electric ranges and water heaters, four had electric ranges but not electric water heaters, four had electric water heaters but not electric ranges, and four had neither electric ranges nor water heaters. Data on electric current and voltage were obtained by recording meters installed at the yardpole and in the house and range circuits. Four farms were metered each week. The meters were moved from farm to farm so that each farm was metered one week in four. Metering of farms was carried on for a year. Ranges and homes were metered for eight months.

The eight months' meter data for ranges are presented in the following ways:

1. Graphs of average electric demand per half hour for all ranges for the metered

reek in each month, of seven-day average
emand by months, and of eight-month av-
rage demand by days.

2. Tabulation of demand characteris-
tics, including highest demand of one min-
ute or more, highest average 30-minute
demand, and demand factor for each range.

3. Tabulations of total minutes in use
of ranges and ovens and minutes "on" of
ovens by three-hour intervals for seven
days for each month.

4. Ratios of oven use to range use and
oven operation to oven use by individuals
and by months.

5. Operation factor for all ranges.

6. Energy consumption for each range
or a metered week of each month and es-
imated consumption for each month.

Maximum one-minute demands of indi-
vidual ranges varied from 4,400 to 9,504
volt-amperes; average 30-minute demands
from 2,945 to 8,098 volt-amperes. De-
mand factors based on one-minute demands
varied from 0.246 to 0.497. The operation
factor for all ranges for all metered per-
iods, 0.102, shows that, during the periods
considered, average use of ranges was
about two hours and 27 minutes per day.
Estimated average monthly energy con-
sumption per range varied from 54 to 283
kilovolt-ampere-hours.

By inspection of ammeter records it was
possible to identify the operation of many
of the electric appliances and to determine
when and how long they were used.

Information on refrigerators and free-
zers is reported individually for each home.
Descriptive information, data on use, and
minimum per cent operating times are
given. All of the families had electric re-
frigerators and all had either freezers,
rented lockers, or both.

Eight months' meter data for water heat-
ers with thermostatic control only are pre-
sented in graphs showing seven-day aver-
age minutes of operation by 30-minute in-
tervals. These water heaters operated

more when the demand of farms was high
and less when it was low.

Two water heaters controlled to be off
from 7:00 a.m. to 11:00 p.m. did not add
to peak loads but operated at times of low
general demand when their controls were
properly set. The average operation time
of all water heaters was 300 minutes per
day.

Minutes of use per hour are tabulated
for laundry equipment, vacuum cleaners,
and other appliances. Tables made for
each home for each metered period show
the information for appliances whose oper-
ation could be identified on meter records.

Descriptive data and information on use
of laundry equipment are reported indivi-
dually for each cooperator. Fifteen homes
had electric washers. In twelve of these
homes, water heaters of some type sup-
plied hot water for washing; in two others
a tank connected to the kitchen range sup-
plied hot water when the range was fired;
in one, water was carried from an outside
pump and heated on the range. Nine of the
ten owners of nonautomatic washers re-
ported doing the entire washing in the same
suds and rinse waters. Owners of non-
automatic washers had from four to fifteen
loads per washing and seven to fifteen loads
per week. All of the homemakers had at
least one thermostatically controlled elec-
tric iron; seven homemakers had ironers;
one ironer was rarely used.

It was possible to identify the operation
of tank vacuum cleaners on many of the
metered records; the operation of upright
cleaners could not be identified.

Meter records were obtained for toast-
ers, a waffle iron and sandwich toaster, a
roaster, four cream separators, a hair
dryer, two space heaters, and a circulator
fan for an oil space heater.

Minutes of use of three water pumps and
one stoker are given by 24-hour intervals
for the metering periods for which records
of operation were available.

## GROWTH OF THE POTATO TUBER[1]

### PHILIP HEATH PLAISTED[2]
Department of Botany and Plant Pathology

Samples of field grown Cobbler potatoes were dug during the late spring and summer and the growth of the tubers from 0 to 200 gm. was studied in terms of cellular components and chemical constituents.

The number of cells per tuber was determined by dividing the volume of typical pith-storage and cortical cells into the volume of the tissue from which the cell was obtained. Both tubers and cells making up the tuber were considered to be spherical. The cell volume was determined by counting the number of cell images that fell in a circle of known diameter, when prepared slides of tuber tissue were mounted in a projection microscope. Soluble nitrogen, reducing, and nonreducing sugars were determined from the 80 per cent alcohol soluble portion; and insoluble nitrogen, starch, wall material, and ash from the residue of the alcohol extraction. The green and dry weights per cell were computed from cell numbers and tuber weights.

Growth of the potato tuber was found to be associated with both increase in cell number and in cell size. Unlike some fruits that have been studied, tubers show no initial period of cell multiplication followed by a period of cell enlargement, for cell multiplication accompanied enlargement over the range of the tuber weights studied. The number of cells per tuber and the volume of individual cortical and pith-storage cells followed a linear relationship when plotted against tuber weight on a log log basis. Taking the antilog of the regression equations for the log log plots gave equations for a set of similar parabolas, which indicated that tuber cells pass through an initial period of relatively great activity, followed by a longer period of relatively less activity. Cell division accompanied enlargement in all phases, being more prevalent in the initial than in the latter

growth stages. The relationship between increase in tuber weight and time showed an initial period of slow accumulation of weight, followed by a period of rapid increase.

Factors considered to be associated with growth, such as volume of individual cortical and pith-storage cells, green weight, wall material, and protein nitrogen in mg. per cell unit, gave high correlation coefficients when plotted as a function of tuber weight on a log log scale. The regression coefficients for increase in cell number with increase in tuber weight was 0.73, indicating a relatively rapid rate of cell division. The other growth factors had regression coefficients between 0.23 and 0.28 with an average of 0.25. The antilog of the regression equations gave a set of equations which described similar parabolas.

Factors associated with differentiation or maturity, such as starch, soluble nitrogen, ash, dry weight, and nonreducing sugars in mg. per cell unit, showed high correlation coefficients when plotted as a function of tuber weight on a log log scale. The regression coefficients for these curves were higher than those for growth factors, averaging 0.33. The antilog of these equations yielded a set of equations which described similar parabolas, but with the larger regression coefficients these parabolas rose more sharply than those described by the equation for growth factors.

The parabolas for growth and differentiation factors indicate a period of rapid accumulation of these factors, followed by a longer period of slower but more constant rate of accumulation. The period of rapid accumulation took place in tubers varying in weights from 39 mg. to 2.0 gm. and is considered to be a transition from stolon to tuber growth.

The persistence of cell division at moderately high rates in a tissue which has many of the characteristics of maturity places the growth of the potato tuber in a special category. Both the growth pattern and the histology of the potato are those of tumerous growth normally associated with high auxin levels. Many of the problems of potato production, such as second growth and hollow heart, appear to be dependent upon this growth relationship.

## GENETIC ASPECTS OF THE RESISTANCE TO A
## LYMPHOMATOSIS TUMOR IN THE FOWL[1]

### ROLLAND P. POIRIER[2]
### Department of Genetics

This report investigates the efficiency of family selection as a means of isolating strains of chickens, which are considerably above or under average in resistance to lymphomatosis tumors. Information is likewise given on the virulence of the tumor cells as they undergo a series of successive passages through living birds.

Table 1 gives a summary of the data obtained by testing three consecutive generations of chicks with an inoculum containing intact cells. The average percentage of survival for the initial population was 36.0. Resistant breeding birds were selected on the basis of family percentage of survival to inoculation, and all birds used as parents had been tested.

### Table 1

#### Summary of Data for Testing of Three Generations of Chicks with Lymphomatosis Tumor Inoculations

|  | Numbers of transfers of tumor | Number of chicks tested | Survivors | Per cent surviving | Mean number of days between inoculation and death |
|---|---|---|---|---|---|
| Generation I | | | | | |
| (unselected) | 2 to 4 | 1996 | 719 | 36.0 | |
| Generation II | | | | | |
| Resistant | 1 to 5 | 1180 | 711 | 60.2 | |
| Control | 1 to 5 | 95 | 26 | 27.3 | |
| Susceptible | 13 to 15 | 384 | 92 | 23.9 | |
| Control | 13 to 15 | 17 | 3 | 17.7 | |
| Generation III | | | | | |
| 1st experiment | | | | | |
| Resistant | 17 to 23 | 518 | 124 | 23.9 | |
| Control | 17 to 23 | 43 | 2 | 4.6 | |
| 2nd experiment (virulent tumor) | | | | | |
| Resistant | 41 to 47 | 92 | 12 | 13.0 | 13.6 |
| Control | 41 to 47 | 93 | 2 | 2.1 | 12.0 |
| Susceptible | 41 to 43 | 30 | 0 | 0.0 | 10.0 |
| 2nd experiment (reduced tumor) | | | | | |
| Resistant | 2 to 7 | 93 | 57 | 61.3 | 28.7 |
| Control | 2 to 7 | 91 | 37 | 40.6 | 23.7 |
| Susceptible | 2 to 6 | 50 | 17 | 34.0 | 26.1 |

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1 a. Chairman of Committee, John W. Gowen, Dept. of Genetics.
   b. Doctoral Thesis No. 1347. Submitted December 8, 1952.
2 a. B.A. University of Montreal, Montreal Que., Canada, 1938. B.S.A. _Ibid_., 1949. M.S. Iowa State College, Ames, Iowa, 1951.
   b. Graduate Assistant, Agricultural Experiment Station.

When inoculated with a comparable tumor, the second generation gave 60.2 per cent survival and the third generation 61.3. The method of preserving the tumor has produced an increase of virulence in some of the inoculums used. Birds of the resistant selection in Generation III were tested with the more virulent tumor and they showed better survival than either a random group of chicks or lines select-

ed for susceptibility. The differences were statistically significant. The mean number of days between inoculation and death of positive birds was significantly larger for the resistant group than for the control and susceptible groups. These results point to a considerable success in the first year of selection for resistance followed by an apparent standstill in the second year.

Selection for susceptibility was done on the basis of family performance of sibs and the birds used for breeding were not themselves tested. Generation II susceptible selections showed a survival percentage of 23.9, which was lower than that of the original population. But in the same test, a group of random chickens, used as control, had a lower survival rate of 17.7 per cent, indicating that the reduction in the susceptible group was probably due to an increase in the virulence of the tumor which had gone through a large number of transfers. The testing of the third generation confirmed this opinion. The birds selected for susceptibility were compared with a control when tested with both the virulent and the reduced inoculums. In both cases, the differences in survival rates were not statistically significant. When mean numbers of days from inoculation to death were investigated, the selected group had more days of survival than the control.

The tumorous material was kept by serial passages through living birds. Changes in tumor virulence, noticed during these passages, appeared to come about suddenly, and they were usually in the direction of increased virulence.

Many important differences were noted in the behavior of these two kinds of inoculums. Rates of survival were compared on a large group of chickens. The virulent had a survival percentage of 6.5, whereas the reduced had 47.4 per cent. In the same experiment, a comparison of number of days between inoculation and death of positive birds gave 13.6 days

for the virulent and 28.7 days for the reduced inoculum. The virulent inoculum caused a generalized effect, observed in the internal organs, in 84.6 per cent of the positive birds, while with the reduced inoculum only 19.8 per cent of the cases; became generalized. Breast tumors, livers and spleens were weighed in a number of positive birds and these weights were compared to those of normal chicks of the same age. The virulent inoculum, on the average, has increased the breast muscle 2.3 times, whereas the reduced has produced a tumorous muscle weighing 7.5 times the normal. With the liver, the situation was reversed. The virulent inoculum caused an average increase of 2.5, whereas with the reduced inoculum the livers averaged 1.1 times the normal. For the spleen, the virulent inoculum seems to have increased the mean weight to some extent, whereas the reduced changed the weight very little.

A study on the immunizing effect of the inoculated tumor has shown that survivors of highly lethal doses could resist further inoculation of the same number of cells. This phenomenon may be interpreted as a real instance of immunization, or it may be argued that the birds, with the necessary genotypes to resist a first inoculation, had the same genotypes to protect them against further testing. Dosages of the order of $N/10^3$ to $N/10^7$, where N is the normal dose, did not immunize the survivors against reinoculation with dose N.

Sex differences were lacking in the reaction of the chicks to the inoculated tumors. With the reduced inoculum, tumors regressed in some birds, leaving them with no apparent aftereffects. It seems likely that regression of a tumor and the absence of all neoplastic growth are two different modes of resistance. However, when progenies of both kinds of survivors were tested simultaneously, the rates of survival were indistinguishable.

## MOLD BRAN AND SUBMERGED CULTURE FUNGAL PREPARATIONS FOR SACCHARIFYING CORN FERMENTATION MASHES₁

### EDWIN LEWIS POOL₂
Department of Chemistry

During the last half-century the uses of ethanol have increased to such an extent that it has become one of the most vital raw materials in the world's chemical in- dustry. Ethanol is produced mainly by the fermentation of blackstrap molasses and by synthesis from ethylene. Fermentation of grains is generally a minor source of industrial alcohol, but during periods of increased alcohol demand grain-fermenta- tion becomes of extreme importance.

Starchy substrates, such as grains, must be converted to fermentable sugars, a pro- cess called saccharification, before alco- holic fermentation by yeast is possible. Barley malt, although it has been used for centuries for saccharification, is relative- ly expensive and does not effect complete conversion into sugars. Fungal prepara- tions have been found to be efficient, eco- nomical replacements for malt. Investi- gation of the preparation of fungal saccha- rifying agents and of methods for the eva- luation of their saccharifying efficiencies is of considerable interest.

A preliminary study of the effect of dif- ferent concentrations of acid for the cook- ing of whole corn mashes and mashes com- posed of the various mill fractions of corn was made. The minimum concentration of acid necessary for proper thinning of the

mashes was found to be 0.06 normal sul- furic acid. No evidence was found indi- cating the production of a toxic factor by the action of such a concentration of acid on whole corn or any mill fraction during cooking.

Mold brans and submerged culture pre- parations were made from Aspergillus niger NRRL 330, Aspergillus niger NRRL 337, and Aspergillus oryzae ISC 38-b. At optimum levels, the alcohol yields from corn mashes saccharified by submerged culture and mold bran from A. niger 330 were, respectively, 5.44 and 5.38 proof gallons per standard bushel, from A. niger 337 were 5.28 and 5.30 proof gallons, and from A. oryzae 38-b were 5.13 and 5.38 proof gallons per bushel. Submerged cul- tures of the two A. niger strains were grown on a medium consisting of 5 per cent corn and 5 per cent distillers' dried solu- bles. The optimum medium for A. oryzae 38-b, determined experimentally, con- sisted of 3 per cent corn and 3 per cent distillers' dried solubles. The initial pH in all submerged cultures was adjusted to 5.2.

The results of the experimental fermen- tations are found in Table 1, in which the optimum level of each mold preparation is indicated as per cent, on a dry basis, of

Table I. Summary of Data for Mold Preparations

| Mold preparation | Alcohol yield, proof gal/bu. | Optimal level, per cent | Intercept value | Alpha- amylase units/gm. | Maltase, units/gm. | Limit Dextrinase units/gm. |
|---|---|---|---|---|---|---|
| Sub. cult. | | | | | | |
| 330 | 5.44 | 4.72 | 0.289 | 20.9 (1.8)* | 70.4 (6.06 | 60.5 (5.2) |
| 337 | 5.28 | 6.89 | 0.0202 | 192 (16.5) | 59.1 (5.08) | 123 (10.6) |
| 38-b | 5.13 | 7.26 | 0.0150 | 259 (14.1) | 41.1 (2.24) | 58.6 (3.2) |
| Mold Brans | | | | | | |
| 330 | 5.38 | 3.62 | 0.110 | 25 | 129 | 106.5 |
| 337 | 5.30 | 3.67 | 0.0202 | 113 | 88.5 | 109.7 |
| 38-b | 5.28 | 4.55 | 0.0108 | 230 | 81.5 | 89.1 |

*Values in parenthesis are in units per ml.

1 a. Chairman of Committee, L. S. Under- kofler, Dept. of Chemistry.
   b. Doctoral Thesis No. 1324. Submitted July 17, 1952.
2 a. B.S. Iowa State College, Ames, Iowa, 1943.
   M.S. Ibid., 1949.
   b. Graduate Assistant, Dept. of Chemistry.

the total grain bill. The data for enzyme activity determinations and graphical in- tercepts, according to the method of Reese, Fulmer, and Underkofler (1), are also in- cluded in the table.

Analysis showed submerged and bran cultures of A. niger 330 were highest in

maltase activity and lowest in alpha-amylase. Cultures of A. oryzae 38-b were highest in alpha-amylase and lowest in maltase and limit dextrinase. Cultures of A. niger 337 were highest in limit dextrinase and intermediate in alpha-amylase and maltase.

Slight correlation seemed to exist between alcohol yields and maltase activity, but there was no correlation for the other enzymes. However, the optimum level of a saccharifying agent for maximum alcohol yield cannot be predicted from the maltase activity.

Although the short fermentation test me-

thod of Reese, et al (1) is applicable for determining the optimum levels of similar fungal saccharifying preparations from the same mold strain, results indicated that it cannot be used to compare preparations produced by different mold strains nor by the same strain cultivated in different manners.

### REFERENCE

1. Reese, H. D., E.I. Fulmer, and L.A. Underkofler. Evaluating fungal amylolytic materials for saccharifying fermentation mashes. Anal. Chem. 20:348-53. 1948.

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## ROLE OF CALCIUM AND RELATED IONS IN PROLIFERATION OF LACTIC STREPTOCOCCUS BACTERIOPHAGE₁

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The effects and mode of action of calcium and several additional ions in the lactic streptococcus bacteriophage system were investigated. A calcium-deficient, partially chemically defined medium prepared from tryptophane assay medium (Difco Laboratories) supplemented with xanthine, glutamine, asparagine, sodium thioglycolate, and sorbitan monooleate was used. Mode of action of stimulatory ions was studied using techniques that determine such characteristics of virus multiplication as rate of adsorption to host cells, length of time from adsorption to liberation of new virus (latent period), period over which virus is liberated (rise period), and number of virus particles produced per infected cell (burst size).

The calcium-deficient medium supported continued growth of all lactic streptococcus cultures studied. Increase in numbers of bacteriophages on actively growing host bacteria occurred in no case unless the medium was supplemented with calcium or certain related ions. Rate of bacteriophage proliferation was related to concentration of calcium added, up to a

limiting calcium level. Calcium requirement for rapid virus increase was associated not with the bacteriophage or host bacterial strain alone, but was characteristic of the bacteriophage-organism combination. Several bacteriophages attacking the same host may have different calcium requirements, and the same bacteriophage acting on different hosts may require different levels of this ion for rapid multiplication on each of the several hosts. Greater amounts of calcium were required for rapid proliferation as indicated by mass lysis, when small numbers of bacteriophage particles were added than when a heavier inoculum was used. This probably was due to greater ability of the larger inocula to overgrow the host culture, at a given calcium concentration, before the bacteria became unsuitable as bacteriophage substrate. Proliferation of bacteriophage on a host growing in different media, or in medium containing various levels of calcium, failed to influence calcium requirement of virus progeny in the limited studies that were undertaken. Propagation of a bacteriophage on various susceptible hosts in some cases resulted in virus progeny with different calcium requirements than the parent bacteriophage. This is evidence for host-induced virus change.

A given bacteriophage was found to produce different titers against various cultures susceptible to it. The pattern of these titers was constant. However, virus progeny from propagations of bacteri-

phage on different susceptible hosts pro-
duced different titer patterns against a
series of susceptible cultures than the
parent bacteriophage. Such change in the
bacteriophage was rapid, and following
the first propagation on a new host, sub-
sequent propagations failed to alter titer
pattern of virus progeny. Host-induced
virus change would be expected to be ex-
tremely significant from a genetic as well
as epidemiological standpoint.

All of the experiments on mechanism of
ion action led to the conclusion that the re-
lationship between calcium concentration
from $2x10^{-4}$ M to $48x10^{-4}$ M and rate of
bacteriophage proliferation was due to a
dependence of bacteriophage on calcium
for "invasion" of host cells. The term in-
vasion as used here means penetration by
attached bacteriophage or orientation of
reactive groups of bacteriophage and host
leading to penetration.

. A function of calcium in bacteriophage
invasion was suggested by the following
observations. The requirement for calci-
um by lactic streptococcus bacteriophages
could not be explained by an effect of this
ion on rate of host bacterial growth, on
stability of free bacteriophage, or by the
slight influence of this ion on rate of bac-
teriophage adsorption (attachment) to host
cells. Further, calcium functioned in the
very early stages of the bacteriophage
growth cycle, some virus-host complexes
producing new virus after calcium had been
available for as little as 38 seconds. Us-
ing one-step growth curves and single in-
fected cell experiments, it was reasoned
that if calcium functioned principally in
some stage of the intracellular multiplica-
tion process, then the greater bacterio-
phage proliferation rate with increased cal-
cium concentration should be associated
with either a shortened latent period or an
increased burst size at the higher levels
of calcium. No such effects were observed.
Similarly, if calcium functioned in the pro-
cess of virus liberation following intracel-
lular multiplication, a shortened rise per-
iod or increased burst size might occur
with increased calcium concentration.
This, too, was not observed. On the other
hand, if calcium were concerned in the
process of invasion, then concentration
should have little effect on the character-
istics of the bacteriophage growth cycle as
such, but rather should influence the num-
ber of these cycles that could occur. This
was found to be the case. The conclusion
that calcium functions in bacteriophage

invasion is supported by the nature of bac-
teriophage growth curves obtained when
calcium was added to systems containing
bacteriophage adsorbed to cells in absence
of this ion, the lack of a killing action on
cells by bacteriophage adsorbed in absence
of calcium, and the early requirement for
this ion. Suspension of either virus or host
in calcium-containing medium did not re-
sult in irreversible binding of sufficient
calcium to satisfy the requirement for pro-
liferation of the virus when organism and
bacteriophage so treated were combined
in calcium-deficient medium.

Strontium, barium or manganous ion
replaced calcium as a requirement for
proliferation of several bacteriophages
studied. However, at equimolar concen-
tration, these ions were less effective
than calcium. Mechanism studies indicated
that these ions function in the same manner
as calcium. Magnesium, nickel, cobal-
tous, zinc, cupric, cadmium, ferrous, alu-
minum, chromic, and lithium ions failed
to replace calcium in the calcium-free
medium.

None of thirteen cations studied in com-
bination with calcium (with the possible
exception of potassium in very high con-
centration) appeared antagonistic to calci-
um action in a manner that could not be
explained by direct toxicity to either virus
or host. In contrast, magnesium or co-
baltous ions combined with a minimal con-
centration of calcium, resulted in more
rapid bacteriophage proliferation than cal-
cium alone. The nature of this effect was
studied in some detail because these ions
appeared ineffective in absence of calcium.

Stimulatory action of magnesium or co-
baltous ions combined with calcium could
not be explained through an effect upon
rate of host bacterial growth, bacterio-
phage adsorption, length of latent or rise
periods, or burst size. They did not ap-
pear to increase the physiological capac-
ity of bacteriophage-host complexes to
produce virus, for when combined with
optimum concentration of calcium they had
no noticeable stimulatory effect. As in
the case of calcium, they appeared to ex-
ert their effect within the early minutes of
virus-host association. Their action ap-
peared closely associated with that of cal-
cium, and they perhaps function through
a sparing action for calcium, substituting
for part of the calcium requirement in
presence of sub-optimum levels of this
ion.

QUANTITATIVE STUDIES OF THE ELUTION OF NEODYMIUM FROM
HIGH CAPACITY CATION-EXCHANGE RESIN WITH DILUTE
CITRIC ACID-AMMONIUM CITRATE SOLUTIONS[1]

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The elution of neodymium from Nalcite HCR resin beds with 0.1 per cent citric acid-ammonium citrate solutions was investigated and quantitative measurements were made to determine the distribution of ions between the aqueous and resin phases.

In preliminary experiments it was found that the adsorbed neodymium bands could be observed and photographed under blue light and that the formation of the insoluble compound, $NdCit \cdot 2H_2O$, in the resin bed could be prevented by using a small initial load, a fast flow rate during the first stages of development or excess hydrochloric acid during the adsorption step.

The rate of movement of the front edge of the adsorption band was found to be dependent solely upon the rate of addition of ammonium ion from the eluant; this fact allowed the break-through volumes to be calculated precisely. The break-through volume, in liters, was calculated by dividing the number of equivalents of hydrogen-form resin remaining in the column after the neodymium was adsorbed by the number of equivalents of ammonium ion per liter of eluant.

The capacity of the resin for monovalent and trivalent ions was determined. Since in both cases a capacity of 4.26 meq. per gram of air-dried hydrogen-form resin was observed, it was concluded that neodymium was adsorbed only as a tripositive ion. This conclusion was substantiated further by quantitative analyses for both ammonium ion and neodymium in the resin during elution.

From theoretical considerations and the behavior of the adsorbed bands the following quantitative relationships were formulated:

$$\frac{Nd_R^T}{Nd_S^R} = \frac{NH_{4R}^+}{NH_{4S}^+} = \frac{H_R^+}{H_S^+} = \frac{Q}{NH_4^+}$$

in which $Q$ is the capacity of the resin; $NH_4^+$ is the concentration of ammonium ion in the eluant; the subscripts, $R$ and $S$, re-

fer to the resin and aqueous phases, respectively; and the superscript, $T$, indicates the total neodymium concentration of the eluate. Experiments showed that these relationships were valid for the pH range studied.

Analytical data from five experimental runs were plotted and it was found that the concentration of ammonium ion and total neodymium in the eluate and the concentration of ammonium ion in the eluant were linear functions of one another. Equations were derived which related the slopes of the curves to each other.

It was shown that the concentration of hydrogen ion in the resin phase was so low, compared to the concentration of ammonium and neodymium ions in the equilibrium band, that it could be neglected in the material balance equation for the resin phase. From a knowledge of the total amount of neodymium adsorbed and the ratio of neodymium to ammonium ion in the eluate, it was possible to calculate the approximate length of the adsorbed band under equilibrium conditions.

From the material balance equation for the aqueous phase it was shown that the sum of the ammonium-ion and total neodymium concentrations in the eluate was always equal to the concentration of ammonium ion in the eluant in the pH range investigated.

Evidence was presented to show that the predominant complex neodymium ion was $NdCit_2^=$; by making the oversimplified assumption that this was the only neodymium-citrate complex present, the pH values of the eluates and other pertinent data could be calculated with a fair degree of accuracy. It was pointed out, however, that for highly precise calculations one must consider the ionization of $NdCit_2^=$ and the association of this complex with hydrogen ion at lower pH values to give $HNdCit_2^=$.

In order to completely solve the fundamental equations for this system it is necessary to know either the values of the equilibrium constants and the ionic activity coefficients, or to know the concentration of either the ammonium ion or the total neodymium in the eluate as a function of the pH or the ammonium-ion concentration of the eluant. The latter relationships were determined experimentally.

The mechanism of self-sharpening of the rare-earth bands and the effects of channeling upon narrow bands were discussed in detail.

## THE TITANIUM-VANADIUM SYSTEM[1]

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Department of Chemistry

A survey has been made of the titanium-vanadium system and a fairly complete phase diagram is presented. Most of the alloys were prepared by arc melting together the component metals under purified argon. Sponge titanium used for this purpose was obtained from two commercial sources, while the vanadium was prepared in the laboratory by calcium reduction of vanadium, using sulfur in one case, and iodine in the other as booster.

In addition, a few alloys were prepared directly by coreduction of the mixed oxides with calcium, and the use of sulfur as booster. The alloys, while fairly satisfactory in the high vanadium range, were unsatisfactory in the high titanium region. The high titanium alloys were low in yield, and, perhaps due to dissolved oxide, extremely brittle. Coreduction of the mixed oxides of titanium and vanadium yielded alloys enriched in vanadium, which makes it difficult to control composition by this method. For example, a mixture of oxides which, if completely reduced should have given a 60 per cent vanadium alloy, yielded instead an 80 per cent vanadium alloy. Consequently, this method is not an entirely satisfactory one, and was not employed as the principal one for preparing alloys to be used in these studies.

At high temperatures, the body-centered cubic titanium and vanadium were found to be completely miscible, and gave a complete series of solid solutions from pure titanium to pure vanadium. The microstructures of the solid solutions did not appear to be entirely single phase, due perhaps to the presence of some impurities in small amounts. The results of x-ray studies, however, clearly indicate that the lattice parameter of the body-centered cubic beta phase of vanadium is increasingly expanded as the larger titanium atoms are added in substitutional solid

solution. The most titanium that it was found possible to retain in the beta form on water quenching to room temperature corresponded to approximately the 18.5 per cent vanadium (81.5 per cent titanium) alloy. More titanium than this in solid solution apparently caused the beta solid solution to undergo a martensitic type transformation, to give secondary alpha and beta solid solution with a lattice parameter corresponding to that of the 18.5 per cent vanadium alloy.

As a result of metallographic studies, the transition that takes place in pure titanium at 885° C. was shown to be progressively lowered by additions of vanadium to titanium. Thus, the beginning of this transition on cooling is lowered to approximately 600° C. by addition of 23 per cent vanadium to the titanium. The presence of about 0.25 per cent oxygen in the titanium-vanadium alloys was indicated to raise the beta to alpha plus beta transition temperature. This amounted to about 50° C. at the 10 per cent vanadium composition, and is in accord with the elevation of the transition temperature of pure titanium by additions of oxygen.

The solid solubility of vanadium in the hexagonal form of commercial titanium, containing about 0.25 per cent oxygen, was indicated from x-ray and metallographic evidence to be less than 1 per cent at 700° C.

The melting point of pure vanadium produced by calcium reduction of the pentoxide, using either sulfur or iodine as booster, was determined as $1860 \pm 20°$ C. This high melting point of vanadium is in line with the theoretical considerations of Pauling. Vanadium, with an intermediate number of cohesion electrons, should have a melting point between that of titanium and chromium. Appreciable amounts of oxygen in vanadium definitely increase its melting point.

The melting point of crystal bar titanium was determined at 1680° C. under a 0.03 to 0.08 micron vacuum by the same method as that employed for vanadium. This melting point is lower than literature values for titanium metal. Slight amounts of oxygen or nitrogen in titanium produce a decrease in its melting point. For ex-

ample, three successive meltings of this crystal bar metal under similar vacua to that of the first melting reduced the melting point to 1633° C.

The solidus curve and the approximate liquidus curve were determined for this alloy system. A minimum of about 1570°C was found in the liquidus at the 30 per cent vanadium composition. Reaction of the high vanadium alloys with appreciable amounts of oxygen, nitrogen, or both, caused by heating the alloys in a 1.1 micron vacuum, resulted in a marked increase in melting temperature and hardness of these alloys. In the case of the 51.7 per cent vanadium alloy, the increase in melting temperature amounted to about 85° C, and the increase in hardness to 10 points of the Rockwell "A" scale, i.e., from 65 to 75.

The emissivities of the metals and alloys were determined in a 0.1 micron vacuum in order to follow the progress of surface oxidation during the melting temperature determinations, and for estimating the melting temperature of the alloys. The alloys and metals heated under the above conditions usually showed a decrease in the emissivity as the temperature was increased. Vanadium showed, in addition, an initial increase in emissivity before this decrease. The alteration of the emissivity of each alloy or metal as the temperature is increased, is assumed to be due to progressive superficial absorption of oxygen or nitrogen. The initial increase in emissivity observed for vanadium may be explained by the effect of low impurity level on this property, and the eventual decrease observed under the conditions of continued oxidation may be attributed to the loss of free electrons by the metal. Other high melting reactive metals may be expected to behave in a similar manner when heated in the presence of traces of reactive gases. Melting temperatures, as estimated from the highest observed surface temperature (related to emissivities), and reference to a plot of observed surface temperature against true temperature for the metal or alloy were found to be comparable to those determined by the method of hole closure, in most cases.

The approximate surface tensions of the metals and alloys were determined by the method of sessile drops on the solidified arc melted buttons. This method gave lower values than the absolute values of the literature, when applied to several metals. For the titanium-vanadium alloys, the surface tensions and the estimated surface enthalpies, as determined on approximately constant volume drops,

appear to parallel the liquidus curve and, correspondingly, exhibit a minimum at about the 30 per cent vanadium composition. The equation of Stefan, suitably modified, appears to be a satisfactory relationship between surface tension and melting temperature for the titanium-vanadium alloys. It should be possible to modify the sessile drop method and thus obtain absolute values of the surface tension of metals and alloys.

The alloy densities were measured. The curve of density against composition may be interpreted as indicating some slight incompatibility of the two metals.

Electrical resistivities of the annealed metals and alloys in the beta solid solution region show an almost linear increase from vanadium to a maximum at about the 20 per cent vanadium (80 per cent titanium) alloy, which is apparently close to the maximum amount of titanium that can be retained conveniently in beta solid solution. From this composition, the alloy resistivity decreases regularly to the limiting value for commercial titanium.

From the measured resistivity change of a sample subjected to an annealing treatment at lower temperatures, ordering was at first suspected for the 50 atomic per cent composition. The observed drop in resistivity for this alloy may be equally well explained by the existence of a two phase region that is slow to attain equilibrium at the low temperature (500° C). The latter explanation is probably the more correct.

The titanium-vanadium system shows a maximum hardness and tensile strength in the high titanium region, and another small maximum towards the center of the beta solid solution region. A hardness maximum was also observed for an alloy containing 2.5 per cent vanadium, The hardness of this latter alloy decreases as it is quenched from successively lower temperatures.

The air oxidation rates of all titanium-vanadium alloys treated in air at both 775° C. and 600° C., were considerably greater than that of titanium alone. At both temperatures, a peak in the oxidation rate occurs at about the 30 per cent vanadium composition. For the 775° C. tests, alloys containing more than 70 per cent vanadium oxidize very rapidly, exhibiting a liquid oxide film over the sample.

Representative titanium-vanadium alloys covering the entire system showed excellent corrosion resistance in 315° C. steam for the duration of a 125 hour test.

Differential dissolving potentials of the titanium-vanadium alloys against titanium

:ere roughly reproducibly constant for
:ach alloy when quenched from a given
*mperature. The magnitude of the volt-
:ge difference is an approximate measure
f the relative rates of solution of two
:pecimens in a given solvent. A marked
:hange in the potential, on passing from

the single phase beta to the two phase al-
pha plus beta region, was not observed
for this alloy system. The maximum rate
of solution in hydrofluoric acid was shown
by the hardest alloy at a 750° C. quench,
i.e., the 10.7 per cent vanadium alloy,
which is two phase at that temperature.

## RESOLUTION OF GLUTAMIC ACID WITH·2-AMINOBUTAN-1-OL₁

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The specific problem of this study was
ɔ investigate a simple resolution of DL-
:lutamic acid. D-glutamic acid is usually
:repared as needed in most laboratories
:y methods of resolution which are time-
onsuming and involve many steps. Syn-
:hetic glutamic acid may soon be able to
ompete with that from natural sources.
·ince the monosodium salt of L-glutamic
.cid is used as a condiment, a resolution
:f the synthetic DL-glutamic acid would
·e necessary.

The exact role of the atypical D-glutamic
.cid in natural processes has aroused con-
:iderable interest since reports were pub-
:ished that D-glutamic acid appears in tu-
mor tissue. Literature concerning this
.ontroversial metabolic problem expressed
:he additional need for preparative method-
:logy to aid in the clarification of the nor-
mal and abnormal physiological function
:f D-glutamic acid.

The resolution of 2-aminobutan-1-ol
:was accomplished by reacting equimolar
amounts of 2-aminobutan-1-ol with (+) tar-
:aric acid to form (-) 2-aminobutan-1-ol
.+) hydrogen tartrate which precipitated
while the diastereomer did not. The salt
yielded (-)2-aminobutan-1-ol upon adjust-
ment of the pH to 10.6 with calcium hydro-
:ide. The over-all yield was 56 per cent.

The resolution of DL-glutamic acid with
:-) 2-aminobutan-1-ol was brought under
control. The reaction of equimolar quan-
:ities of (-) 2-aminobutan-1-ol and DL-
glutamic acid resulted in a crop of (-) 2-
aminobutan-1-ol-D-glutamate in a yield
of 68 per cent, m.p. 146-147°, $[\alpha]_D^{22}$ =
-3.3°. Subsequent smaller crops yielded

36 per cent of (-) 2-aminobutan-1-ol-L-
glutamate, m.p. 115-117°, $[-\alpha]_D^{22}$ = -9.7°.
Each salt was decomposed by the addition
of HCl until the pH reached 3.2, the iso-
electric point of glutamic acid. Then two
or more volumes of ethanol were added to
precipitate a 96 per cent yield of optically
active glutamic acid. The over-all yield
was 65 per cent of D-glutamic acid and
35 per cent of L-glutamic acid.

There was no significant difference in
the approximate solubilities of (-) 2-amino-
butan-1-ol-D-glutamate, 1.2 g. per 100
ml. of 83 per cent ethanol by volume, and
(-) 2-aminobutan-1-ol-L-glutamate, 1.1
g. per 100 ml. of 83 per cent ethanol by
volume. There was no significant differ-
ence in the approximate solubility over a
range of alcohol-water solutions from 61
to 95 per cent ethanol by volume. How-
ever, 16 g. per 100 ml. of 83 per cent
ethanol of D-glutamate brought 13 g. per
100 ml. of L-glutamate brought 31 g. per
100 ml. of D-glutamate into solution.
Therefore, the diastereomers had a solu-
bilizing effect on each other.

The resolution of 2-aminobutan-1-ol with
L-glutamic acid was successfully carried
out. The reaction of equimolar amounts
of 2-aminobutan-1-ol and L-glutamic acid
yielded 64 per cent of (+) 2-aminobutan-1-
ol-L-glutamate, m.p. 146-147°, $[\alpha]_D^{22}$ =
+3.2°, and 63 per cent of (-) 2-amino-
butan-1-ol-L-glutamate. The former salt
was decomposed with HCl to give an alco-
hol solution of (+)2-aminobutan-1-ol hydro-
chloride. The recovery of L-glutamic acid
from the salt was 97 per cent. The (+) 2-
aminobutan-1-ol hydrochloride was decom-
posed by adjusting the pH to 10.6 with NaOH
or Ca(OH)₂ and NH₄OH to give a 61 per cent
yield of (+) 2-aminobutan-1-ol.

D-glutamic acid reacted with 2-amino-
butan-1-ol to yield 78 per cent of (-) 2-
aminobutan-1-ol-D-glutamate. A 24 per
cent yield of (+) 2-aminobutan-1-ol-D-
glutamate was recovered during this sep-

aration. This corroborates the results of the separation mentioned in the previous paragraph.

DL-Aspartic acid did not follow the precipitation pattern of DL-glutamic acid when the 2-aminobutan-1-ol salt formed. L-Aspartic acid of 70 per cent optical purity was obtained whereas optically pure D-glutamic acid was recovered in the anala-

gous resolution of DL-glutamic acid.

Leucine and phenylalanine did not form salts with 2-aminobutan-1-ol. Leucine and glutamic acid were separated with 2-aminobutan-1-ol; the glutamic acid formed a salt and dissolved whereas the leucine remained insoluble. The salt was decomposed to precipitate the glutamic acid.

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## VARIATION AND INHERITANCE OF SEED FERTILITY AND SEEDLING VIGOR IN BROMUS INERMIS LEYSS.[1]

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Twenty $S_0$ clones of brome grass and $S_1$ segregates from each were studied to obtain information on the extent of variation and inheritance of open-pollination seed fertility and combining ability for seedling vigor, the relationship between and the effect of inbreeding on these two attributes, and the possibilities of using greenhouse tests for evaluating seedling vigor. A replicated, space-planted topcross nursery containing the 20 $S_0$ clones and 10 $S_1$ segregates from each together with a common pollinator variety, Fischer, provided the material for study. All selections originated in the southern varieties; Fischer, Lincoln, and Achenbach. Combining ability for seedling vigor was determined by using topcross progenies grown in split-plot arrangements in the greenhouse and field. Four clonal families were tested in the greenhouse and 18 families in the field. The latter experiment also contained 22 additional topcross progenies and commercial strains. Seed fertility of all 20 $S_0$ clones was investigated for two years and of eight selected $S_1$ families for one year. It was evaluated by determining the number of florets per panicle, number of seedlings per panicle and proportion of seed-setting florets, termed fertility percentage or fertility

Statistically significant differences in seedling vigor among clonal families were obtained under field conditions and gave evidence of segregation for combining ability within seven families. $S_1$ topcross

progenies averaged about 75 per cent of their parental performance when harvested at two months of age in the greenhouse and about 96 per cent when harvested at the end of three months in the field. This indicated a transitory inbreeding depression attributed to maternal influence on seed size. Heritability for seedling vigor in terms of the regression of progeny means on parents x 100 was 25.65 per cent. The corresponding "b" and "r" values were not statistically significant. The correlations between weights of tops and roots and weight of tops and plant height of topcross progenies in the greenhouse were 0.91 and 0.67 (n = 43), respectively. The degree of association between the greenhouse and field test was low (r = 0.25; n = 43), probably because of unsatisfactory control of environmental variation in the greenhouse.

Of three fertility attributes studied, fertility itself was given primary attention since it was postulated that a proportion rather than an absolute number of fertilized female gametes was the inherent plant characteristic. In 1951, mean fertility, number of florets, and number of seedlings per panicle of the $S_0$ clones exhibited a range from 23.80 to 73.40 per cent, 206 to 398, and 67 to 223, respectively, with corresponding grand means of 51.60 per cent, 275, and 142. Repitition of the test in 1952 gave an interannual correlation of 0.68 (n = 58) for fertility, but the interaction between clones and years was statistically significant. All attributes appeared to be primarily under internal control, more so for fertility than for florets. Genetic and environmental path coefficients in 1951 were 0.982 and 0.189, respectively, for florets.

On the basis of 1951 fertility, three high-, two medium-, and three low-fertility $S_0$ clones were chosen for study of their

$p_1$ progenies. Parent-progeny correlations for fertility and florets were 0.68 and 0.84, respectively, and the corresponding herit-ibilities 49.40 and 38.34 per cent $(n = 8)$. Most families exhibited wide segregation for both characters, the range for fertility extending from 0.70 to 75.80 per cent and for florets from 140 to 418. Six $S_1$ families were about 60 per cent as fertile as their $S_0$ parents, while the other two were 96 and 131 per cent as fertile, respectively. Relative to florets, the four high $S_0$ clones exhibited about 20 per cent inbreeding de-pression in their $S_1$ progenies, while the other four $S_1$ means showed 8 per cent im-provement over their $S_0$ parents.

On the average, fertility appeared large-ly independent of the number of florets but highly associated with number of seedlings. Weight of seed per weight of panicle and fertility gave a "r" value of 0.94 $(n = 20)$. A negligible degree of association was found between fertility and certain other agrono-mic characters such as yield, seedling vigor, and panicles per unit area.

Based on the results of these experi-ments it was concluded: (a) that clones differ in general combining ability for seed-

ling vigor, though this character appeared subject to a high degree of environmental influences and was low in heritability. It would appear that selection both among and within families may lead to strains that are superior to the present standards in this regard. However, more rigid envi-ronmental control would be necessary if seedlings were to be evaluated effectively in the greenhouse. (b) Number of florets were considered to be primarily under con-trol of a large number of loci with additive effects. Fertility was considered to be de-termined both by meiotic behavior and bv genes affecting the level of general fertility. A tendency of fertility to decrease as a consequence of inbreeding may warrant further study of fertility in cross-pollina-tion progenies derived from selfed lines. Number of seeds was considered a function of the two other attributes, though its ex-pression may be affected by the conse-quences of inbreeding depression in lower-ing plant vigor. (c) The relationship of fertility to other agronomic characters in-dicated that it would be feasible to select and recombine strains with high fertility and vegetative vigor.

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# RESPIRATION OF MAIZE[1]

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The development of government storage of maize during recent years has empha-sized the need of more knowledge of the behavior of this grain. The present study was undertaken to determine the effects of moisture content of grain, temperature, $O_2$ depletion accompanied by $CO_2$ accumu-lation, dormancy, and the presence or ab-sence of micro-organisms on the respira-tion of corn grain under controlled, labo-ratory conditions. It is assumed that data obtained will be of value in the solution of practical storage problems as well as in-dicative of the physiological responses of this plant material.

Moistened grain, with 15-23 per cent moisture, was used in studies of tempera-ture, moisture, and seed disinfection ef-fects. Freshly harvested corn ears, with 17-42 per cent moisture, were used to

study effect of dormancy on respiration. Incubators at $8.0°$, $21.0°$, and $30.0°$ C. were used for the study of temperature ef-fects in each level of moisture. Ceresan-M was used to obtain near-sterile grain.

A modification of Kostychev's respira-tion flask was used in the experiments. A mercury-glass seal insures against leak-age of $CO_2$. The gas analyses were made with a haldane-type gas analyzer. Respira-tion rates $(\underline{R})$ were calculated as ml $CO_2/$kg dry grain/day. Since $\underline{R}$ decreased with depletion of $O_2$ and accumulation of $CO_2$ in the flasks, an average rate for the first 10 per cent of $CO_2(R_{10})$ was used in most comparisons.

Experimental Results. With moistened grain, respiration increased exponentially with moisture at all temperatures. When log $R_{10}$ was plotted against moisture per-centages, a comparable logarithmic in-crease of respiration with moisture was obtained which was independent of temper-ature. An equation of the type: $y = ae^{bx}$, described the exponential increase of res-piration with moisture. The increase was

greater at lower moistures, however, with the breaks of the curves varying from 20 per cent moisture at 8.0°C. to 17 per cent at 30°C., and two similar equations were required to describe the complete response. The curves at the lower moisture percentages showed approximately the same values of $b$ with different values of $a$ and $x$. Immature grain had always a much lower respiration rate ($R_{10}$) than moistened grain with a corresponding moisture percentage. The log curves showed the same relationship as moistened grain with the exception that the break in the log curve came at 24.5 per cent moisture and the slopes, or $b$ values, were definitely lower. Germination percentages for 16.7 to 31.2 per cent moisture were from 74 to 100, while the values for the less mature ears containing 32.8 to 41.7 per cent moisture were between 12 and 64. Even when high germination was obtained the germination rate was less, indicating some dormancy.

In the temperature studies, the averages and most of the individual $Q_{10}$'s were those expected of enzymatically controlled, chemical reactions with values near 3, and they emphasize the effect of low temperature in reducing respiration rates in moist grain.

With the method used, respiration occurred in an atmosphere which was continuously decreasing in $O_2$ and increasing in $CO_2$ percentages. The individual $R$ values calculated for each sampling interval were, therefore, indications of the combined ef-

fects of $O_2$ and $CO_2$ on the respiration of corn. With moistened grain, respiration rates dropped rapidly and exponentially with time in all experiments. Relative decreases were no less in the drier samples with their lower respiration rates. Results with immature grain showed the same relationship except that the rates were lower. At 40 and 30 per cent moisture respiration decreased about two-thirds as $O_2$ was exhausted instead of about one-half (in moistened, mature grain), suggesting more sensitivity to the effect of $O_2$ and $CO_2$.

Soaking the grain for 15 minutes in a 1 to 10,000 solution of Ceresan-M eliminated all molds and many samples proved to be sterile when germinated on nutrient agar. Others showed an occasional colony of a very slow growing bacterium, presumably a spore-former. More severe treatments gave complete sterility but injured the corn and were discarded. Data on the respiration of seven control samples of corn and seven Ceresan-M treated samples showed average germination at the end of the experiments was 91 per cent for the controls and 86 for the treated samples. When the respiration of the non-sterile and near-sterile lots were plotted against moisture percentages, the data points gave a satisfactory fit to a single curve, indicating no differences in respiration due to the elimination of all molds and most bacteria. The results indicated satisfactorily that maize grain has a respiration of its own which may increase in an exponential manner with increasing moisture content.

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# CAUSES OF VARIATION IN CALVING INTERVAL OF HOLSTEIN-FRIESIAN COWS[1]

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Department of Animal Husbandry

The main purpose of this investigation was to describe the length of calving interval and its variation, and to determine if it has a genetic basis. Also of interest were the phenotypic and genetic relationships between length of calving interval and the production of milk and fat.

The data were taken from the herds of

1 a. Chairman of Committee, Jay L. Lush, Dept. of Animal Husbandry.
   b. Doctoral Thesis No. 1344. Submitted December 6, 1952.
2 a. B.S.A. Ontario Agricultural College, Guelph, Ont., Canada, 1947.
   b. M.S. Iowa State College, Ames, Iowa, 1950.
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the Iowa State College Holstein herd and the Iowa State Board of Control Holstein herds at Mount Pleasant and Cherokee, Iowa, and covered a period of approximately eleven years, 1940 to 1951.

The frequency distribution of the 1663 calving intervals used in this study deviated markedly from a normal distribution. The modal class was 360 - 380 days with a mean of 413 days or 13.6 months and an overall standard deviation of 78 days. The calving intervals ranged in length from 277 to 884 days.

Age at first calving had practically no influence on length of calving interval. The linear correlations between age at first calving and length of the first, sec-

nd and third calving intervals were
(.034, 0.030 and -0.010, respectively.
Differences in age of cow at time of
calving accounted for 10.3 per cent of
the total variance and 11.7 per cent of
the intra-herd, intra-year variance of
individual calving intervals. The intra-
herd, intra-year correlation of age of
cow at time of calving and the length of
the ensuing calving interval was 0.029,
which indicates that most of the associa-
tion of age with length of calving interval
s not linear.

The records of 222 cows from the Iowa
State College Holstein herd were used in
studying the influence of management on
the length of calving interval. An aver-
age interval of 26 days elapsed from the
time of first estrus until first breeding,
indicating that the length of calving inter-
val is influenced by intentional delay in
breeding. On the average, an interval of
55 days elapsed from time of parturition
until the occurrence of first estrus.

Yearly environmental differences ac-
counted for 4.8 per cent of the total vari-
ance and 5.1 per cent of the intra-herd
variance in individual calving intervals.
The intra-herd correlation between calv-
ing intervals of the same cow was .184
after year effects were eliminated. When
yearly environmental differences were
ignored the repeatability estimate reduced
to .175.

Heritability of differences in length of
calving interval was estimated as .03 $\pm$
.11 by doubling the intra-sire regression
of daughter on dam. The daughter-dam

analysis included the records of 417 dams
and 447 daughters. A heritability value of
.148 was obtained by multiplying the pa-
ternal half sister correlation by four. The
95 per cent fiducial limits on the daughter-
dam estimate were +.24 and -.18. Be-
cause of the large sampling errors, little
confidence can be placed in these estimates
except that heritability probably is rather
low.

Genetic correlations calculated from
these data for the length of calving inter-
val with milk and fat production were both
over one. Because the sampling errors
of such estimates are large they should
probably be considered only as a slight
indication that the true values of these
correlations are probably positive and
rather large.

The intra-herd and intra-year regres-
sions of milk and fat production were such
that for each increase of ten days in length
of current calving an increase of 73.5
pounds of milk and 2.38 pounds of fat
would be expected. The intra-herd re-
gressions of milk and of fat production on
length of the preceding calving interval
indicate that an increase of 60.9 pounds
of milk and 2.30 pounds of fat would be
expected with each additional ten days in
length of the preceding calving interval.

The heritability and repeatability esti-
mates indicate that only a small portion
of the variation in calving intervals is
genetic. It may be concluded then, that
selection would not be very effective in
changing the length of calving interval.

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## ACHIEVEMENT IN CALCULUS ASSOCIATED WITH DIFFERENT
## METHODS OF MEETING PREREQUISITE MATHEMATICS[1]

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Higher education is continually chal-
lenged by the ever-increasing demand
for highly trained professional people.
The degree and amount of training neces-
sary for any given professional person
has been increased as our society be-

comes more and more complex. Engi-
neering education has been affected in
that the strong demand for engineers has
stimulated careful study of engineering
curriculum by leaders in the field. Sev-
eral solutions have been suggested such
as: (1) adding a year to the curriculum,
(2) increasing the college entrance re-
quirements, and (3) revision of engineer-
ing curricula. Exploratory courses have
been tried in some institutions as one
means of improving engineering educa-
tion.

This study was concerned with three
exploratory programs of fulfilling the
mathematics prerequisite to calculus,

for students in the Division of Engineering at the Iowa State College during the years 1948, 1949, and 1950. At this institution one and one-half Carnegie units of high school algebra and one unit of plane geometry are required for admission to college algebra. Many students who entered the Iowa State College had as much as four semesters of high school algebra, two semesters of plane geometry and one semester of plane trigonometry.

In the fall of 1948, students with credit in high school algebra and two semesters of plane geometry were enrolled in college algebra. On the basis of their high school grade average, pre-college entrance examinations, and a mark received on an achievement test, the students who had four semesters of high school algebra and one semester of plane geometry were placed in a special group who took college algebra and plane trigonometry successively in one quarter. Upon the completion of college algebra and plane trigonometry, students received 9 quarter hours of credit toward graduation in engineering.

In the fall of 1949 the entering high school students who had credit in four semesters of high school algebra, two semesters of plane geometry, and one semester of plane trigonometry were enrolled in analytic geometry. However, no credit toward graduation in engineering was given for the courses prerequisite to analytic geometry.

In the fall of 1950, the entering engineering students who had credit in four semesters of high school algebra, two semesters of plane geometry, and one semester of plane trigonometry were enrolled in college algebra and plane trigonometry concurrently. Students in this group met five times per week for five quarter hours of credit toward graduation in engineering. Students who had credit in but three semesters of high school algebra and two semesters of plane geometry took college algebra for five quarter hours and plane trigonometry for four quarter hours. However, they received but five quarter hours of credit toward graduation in engineering.

These three exploratory programs in mathematics were evaluated by contrasting them with each other and also with the usual sequence of mathematics taken during the freshman year. Samples were drawn, so that there were 50 students for each of the three years in the exploratory programs and 100 students for each of the three years in the regular programs.

The criterion by which the programs were evaluated consisted of the course marks received in first quarter calculus. These marks of A, B, C, D, and F were assigned values of 4, 3, 2, 1, and 0, respectively. In addition, any student who did not enroll in calculus was given a score of -1.

The pre-college measures available at the Iowa State College for the three years included in this study were the high school grade average, the scores on the American Council on Education Psychological Examination, and a score on the English placement test.

An analysis of variance without regard to individual differences was made by a two-way classification by year and type of mathematics program. An F-value was computed using the within mean square as the denominator and significance at the 5 per cent level was noted among years. Significance at the 1 per cent level was noted for type of course and for interaction. Another test ignoring student ability was made among the three exploratory courses. A highly significant difference was again noted. This analysis did not give much indication concerning the effectiveness of the program since the groups differed greatly in ability and achievement as indicated by (1) the high school average, (2) scores on the ACE examinations, and (3) the English placement test.

Before undertaking an analysis of covariance, an analysis of regression was made to determine which of the available variables should be used for control. A regression equation was developed for predicting calculus achievement from all four variables. Further analysis revealed no significant loss when two of these variables were eliminated. Thus, for purposes of control, only the ACE scores and the high school grade average were used in the covariance analysis.

The covariance analysis was made by multiple classification consisting of type of program, year, and interaction. When the mathematics programs were evaluated in the foregoing manner, the exploratory courses were superior, although no evidence was available from the interaction to justify a conclusion that any one exploratory program was superior to another.

### UNSYMMETRICAL ORGANOTIN COMPOUNDS CONTAINING FUNCTIONAL GROUPS₁

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The preparation of triphenyltin-lithium from stannous chloride and phenyllithium is a two step process, the first step being nucleophilic displacement of the chlorine atoms bonded to the tin atom as chloride ions by the phenyl anion of phenyllithium to form diphenyltin. The second step involves addition of the phenyl anion to the open octet of the tin atom in diphenyltin to form the complex, triphenyltinlithium. The attraction of the phenyl anion for diphenyltin must indeed be strong as the complex does not appear to be involved in an equilibrium system with its component parts as is evidenced by reactions with gaseous carbon dioxide, Dry Ice, benzophenone and benzalacetophenone. If the complex does dissociate into its component parts, it would be expected that the phenyllithium would react with the aforementioned compounds to form benzoic acid, triphenylcarbinol and diphenyl-β-styrylcarbinol, respectively. In each reaction the only compound formed was teraphenyltin (ca. 10%), and in the last two reactions, good recoveries of the ketones were made.

The complex does not possess sufficient activity to add to the carbon-carbon double bond of trans-stilbene, but it does successfully attack the oxirane ring as is evidenced by the preparation of triphenyl-2-hydroxyethyltin (45%) and triphenyl-2-hydroxy-3-chloropropyltin (27%) by reaction of ethylene oxide and epichlorohydrin, respectively, with the complex.

Triphenyltin-lithium was reacted with a series of organic halides to form the following organotin compounds: triphenylethyltin (36%, m.p. 56-58°), triphenylbenzyltin (20%, m.p. 89-91°), tetraphenyltin (82%, m.p. 227-229°), triphenylmesityltin (39%, m.p. 155-157°), triphenyl-o-methoxyphenyltin (24%, m.p. 129-130°), triphenyl-p-methoxyphenyltin (30%, m.p. 151-152°), triphenyl-p-chlorophenyltin (20%, m.p. 136-139°), triphenyl-2,4-dimethylphenyltin (43%, m.p. 112-115°), triphenyl-2,5-dimethylphenyltin (43%, m.p. 97-99°), triphenyl-2,6-

1 a. Chairman of Committee, Henry Gilman, Dept. of Chemistry.
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dimethylphenyltin (34%, m.p. 116-119°), triphenyl-o-totyltin (25%, m.p. 163-165°) hexaphenylditin (53%, m.p. 229-231°), and triphenylsilyltriphenyltin (71%, m.p. 289-291°).

It was found that when o-substituted aryl iodides were reacted with triphenyltin-lithium a second reaction, along with that of the formation of the unsymmetrical compound, took place. This second reaction is thought to be a halogen-metal inconversion reaction between the complex and the aryl iodide. The products formed by this reaction would be triphenyltin iodide and an o-substituted phenyllithium compound. The latter compound was indirectly identified by conversion to an o-substituted benzoic acid by means of the carbonation reaction, and the hexaphenylditin obtained in the same reaction is believed to arise by reaction of triphenyltinlithium with triphenyltin iodide, as formed.

Complexes other than triphenyltin-lithium may be prepared by substituting other organolithium compounds for phenyllithium. The preparation of symmetrical alkyl and aryl organotin compounds by this method appears to be promixing as the yields of tetraethyltin, tetra-n-butyltin, tetra-p-tolyltin, and tetra-m-tolyltin were in excess of 70%. It was not possible to prepare tetra-o-tolyltin by treatment of tri-o-tolytin-lithium with o-iodotoluene. The steric hindrance presented by the three o-methyl groups probably prevented a successful attack on the halide from taking place. A reaction between this complex and benzyl chloride prepared the desired unsymmetrical compound in only a 2.3 per cent yield.

Triphenyltin hydride (52%) was prepared by the reduction of triphenyltin iodide with lithium aluminum hydride in ether. The hydride was reacted with methyllithium to form triphenylmethyltin (18%), lithium hydride and tetraphenyltin (25%). These results are at variance with those reported by Wittig and co-workers (1).

A reaction between triphenylbenzyltin and phenyllithium proved to be extremely interesting in that the benzyl group was preferentially cleaved by the organolithium compound. This result is an exact reversal of the reaction between triphenylbenzyltin and halogen acid, in which the phenyl group is preferentially removed (2).

The preparation of azo tin compounds by

reaction of triphenyl-p-dimethylamino-phenyltin with p-substituted benzenediazonium chlorides in a buffered solution proved to be a rather unsatisfactory method. It was found that azo tin compounds could be prepared directly and in good yields by reacting triphenyl-m-dimethylaminophenyltin with p-substituted benzenediazonium fluoborates. The following azo tin dyes have been prepared: triphenyl-4-dimethylamino-3-(4'-nitrophenylazo)phenyltin (24%, m.p. 187-189°), triphenyl-4-dimethylamino-3-(4'-bromophenylazo)phenyltin (7%, m.p. 170-172°), triphenyl-4-dimethylamino-3-(4'-chlorophenylazo)phenyltin (5%, m.p. 162-165°), triphenyl-3-dimethylamino-6-(4'-nitrophenylazo)phenyltin (67%, m.p. 205°),triphenyl-3-dimethylamino-6-(4'-bromophenyl-azo)phenyltin (49%, m.p. 199-200°), triphenyl-3-dimethylamino-6-(4'-carboxyphenylazo)-phenyltin (48%, dec. 358°) and sodium 4-(2'-triphenylstannyl-4'-dimethylamino)phenylazobenzoate (97%).

Two of these compounds, triphenyl-3-dimethylamino-6-(4'-nitrophenylazo)phenyltin and triphenyl-3-dimethylamino-6-(4'-bromophenylazo)phenyltin, were tested for their substantivity as dyes. Neither proved to have lasting substantivity.

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# IN VITRO STUDY OF UNIDENTIFIED FACTOR(S) IN CATTLE FEEDS WHICH FAVORABLY INFLUENCES CELLULOSE DIGESTION BY RUMEN MICRO-ORGANISMS[1]

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The purpose of the study was to demonstrate further the existence and some of the properties of this unidentified factor(s) in cattle feedstuffs which favorably influences cellulose digestion by rumen micro-organisms.

In vitro techniques (artificial rumen) were employed throughout the study. The general procedure of this technique included the carrying out of a series of ten consecutive 24-hour fermentations in laboratory flasks under conditions resembling the conditions present in the rumen of cattle and sheep. The flasks were originally inoculated with rumen microorganisms taken from a live animal. To these flasks was added daily a chemically defined basal medium, which contained all the nutrients known to be needed by these micro-organisms. Various feedstuffs or fractions were tested by adding them to other flasks containing the basal medium and observing their stimulating effect upon cellulose digestion over that occurring where the test material was absent.

The results obtained indicated that

there was an unidentified factor(s) in certain cattle feedstuffs which favorably influenced cellulose digestion by rumen micro-organisms.

The distribution of this unidentified factor(s) in feedstuffs appears to be fairly widespread. Protein-rich feeds and other concentrate feeds of plant origin as well as good-quality roughages were found to be potent sources. Also, other materials such as manure extract and yeast were found to be rich sources of this factor(s).

Of the protein feeds soybean oil meal, wheat bran, linseed oil meal, and distillers' dried solubles were the most helpful in supplementing the basal medium. Other feeds giving a smaller stimulating effect were yellow corn, distillers' dark grains, distillers' light grains, dried live yeast, grey shorts and cottonseed meal. Also, roughages such as alfalfa meal, corn cobs, and blue grass hay appeared to contain some of the unidentified factor(s). Feedstuffs showing little or no favorable influence were fish meal, skimmilk powder, yeast feed, meat and bone scraps, and liver and glandular meal. With one exception, combinations of feedstuffs indicated that the stimulatory effect on cellulose digestion was not additive.

The identity of the factor(s) needed by rumen micro-organisms for efficient cellulose digestion is not known. However,

following characteristics or properties are observed from fractionation studies:

1. Rumen micro-organisms do not produce this factor(s) in sufficient quantities in vitro to meet their needs.

2. It is heat stable.

3. It is water soluble and soluble in low concentrations of ethanol.

4. It is adsorbed on Norite.

5. It is not adsorbed on Nalcite HCR and IRA 410 ion-exchange resins.

6. It is destroyed by ashing.

7. It is not removed from aqueous solution by acid and alkaline zinc sulfate precipitation.

8. It does not appear to be an amino acid.

9. It does not appear to be a B-complex vitamin.

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## FACTORS AFFECTING PASSIVE IMMUNITY IN BLOOD-INDUCED LOPHURAE MALARIA OF THE COMMON FOWL[1]

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Agglutination and passive protection tests were conducted with plasmas and sera from normal chickens and from chickens immunized as follows: (1) against both Plasmodium lophurae and erythrocytes from other chickens; (2) against P. lophurae, but not against erythrocytes from other chickens; (3) against erythrocytes from other chickens, but not against P. lophurae.

New Hampshire Red chickens more than two months of age served as sources of the plasmas and sera. Only macroscopic agglutination was recorded in most of the agglutination tests, but the microscope was used in a few instances. In the passive protection tests, the plasmas were administered to chicks infected when nine to 19 days old by inoculation with chicken erythrocytes parasitized with P. lophurae. The results obtained and conclusions drawn are summarized below.

1. Isohemagglutinins were demonstrated in the plasmas or sera of 24 out of 32 chickens which had been immunized with nonparasitized or parasitized chicken erythrocytes, but were evident in the plasma of only one of 14 chickens which had recovered from P. lophurae infections induced with parasitized duck erythrocytes and had never been injected with chicken erythrocytes. Such antibodies were demonstrated also in plasma from one of seven normal chickens tested. The injected erythrocytes rather than the malaria infection itself are be-

1 a. Chairman of Committee, Elery R. Becker, Dept. of Zoology and Entomology.
   b. Doctoral Thesis No. 1392. Submitted May 27, 1953.

2 a. B.S. Rutgers University, New Brunswick, New Jersey, 1949. M.S. Iowa State College, Ames, Iowa, 1950.
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lieved to induce the production of the anti-erythrocytic antibodies present in the plasmas of chickens originally infected and subsequently superinfected by inoculation with parasitized chicken erythrocytes.

2. Freezing and thawing markedly enhanced the agglutinating powers of 16 out of 18 isoagglutinating chicken plasmas tested and slightly enhanced the agglutinating power of one of the other two.

3. Supplements of previously frozen plasmas from other chickens enhanced agglutination by unfrozen chicken isoagglutinating plasmas in 19 out of 22 tests. Supplements of unfrozen plasmas enhanced such agglutination in only eight of 23 tests. Frozen supplements, then, were more effective.

4. Supplements of previously frozen plasmas from other chickens inhibited agglutination by previously frozen chicken isoagglutinating plasmas in 13 out of 19 tests. Supplements of unfrozen plasmas similarly inhibited agglutination in 13 of 16 tests. Frozen and unfrozen supplements were equally effective.

5. Chicken isoagglutinating plasmas agglutinated both nonparasitized and parasitized erythrocytes. Absorption with nonparasitized erythrocytes rendered such plasmas incapable of agglutinating either parasitized or nonparasitized erythrocytes.

6. Passive protection against P. lophurae with plasma from chickens which had been immunized against erythrocytes from other chickens but had never been infected with malaria was effected in all four experiments in which such plasmas were tested. Such plasma was every bit as effective as plasma from chickens which had been immunized against both P. lophurae and erythrocytes from other chickens. Some protection was obtained with plasma from chickens immunized against P. loph-

urae but not against chicken erythrocytes, but it was of a lower magnitude than that conferred by plasmas containing anti-erythrocytic antibodies. The evidence is believed to indicate that most of the passive protection conferred by plasmas from chickens originally infected and subsequently superinfected by inoculation with parasitized chicken erythrocytes is attributable to antibodies induced by the injected erythrocytes rather than by the malaria infection.

7. Normal chicken plasma conferred significant passive protection in one of three experiments in which such plasma was tested.

8. Passive protection was obtained when administration of plasma was begun two days after inoculation, as well as when plasma injections were begun prior to inoculation. No significant protection was evident when plasmas were administered for only two or three days. The protection obtained when plasmas are administered daily starting prior to inoculation is not due merely to removal of the infecting inoculum of parasitized erythrocytes.

9. Comparable protection was afforded by unfrozen and previously frozen plasmas from chickens immunized against chicken erythrocytes but not against malaria. Unfrozen and frozen plasmas are both suitable for use in protection tests.

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## LYOPHILIZATION AND GERM TUBE DEVELOPMENT OF PUCCINIA UREDOSPORES[1]

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A number of mixed and pure race collections of cereal rust uredospores were preserved up to three years with no significant loss in viability in storage and only about a 15 per cent loss during lyophilization. Spores in conventional suspending media did not survive but nonsuspended spores gave good survival. The best results were obtained when the lyophil tubes were held at room temperature during processing. Spores which were prefrozen and dried at a bath temperature of -10°C. or lower gave about 35 per cent loss in processing. Most of the lyophilized spores were stored at 5-10°C. but samples have been stored at room temperature for at least a year and at 35°C. for at least six months with no viability loss. Samples ranging in size from 10 to 500 mg. were successfully processed.

The lyophilized uredospores gave heavy infection on susceptible hosts after three years' storage and pure races maintained their physiological characteristics. Lyophilized spores gave similar infection ratings to nonlyophilized spores of the same

germination value. A number of different inoculation methods were successfully used with lyophilized spores.

Lyophilized uredospores required a rehydration period of at least 24 hours in a saturated moist chamber for maximum germination and, in many cases, also required this rehydration period for maximum infection. The dried spores showed faster rates of rehydration than nonlyophilized spores under the same rehydration conditions, and the extent of water uptake was considerably greater. The processed spores were rehydrated for as long as 110 hours in a saturated moist chamber with no loss of viability.

Rate of drying, during lyophilization, was most rapid in the first 15 minutes. The smaller samples of 10-25 mg. reached constant weight in about 40 minutes while samples of 500 mg. required about 90 minutes. At constant weight, the spores contained about 2-3 per cent water, on a fresh weight basis.

The vacuum (10-250 microns) had to be maintained for prolonged viability. Spores sealed under a water pump vacuum of 12 mm. lost viability within a few days.

Uredospores processed by the modified Barratt-Tatum technic showed no significant loss in viability up to one year's storage when the desiccants were removed after three hours. When the desiccants were left in the lyophil tubes, viability declined rapidly.

As high as 40 per cent "vesicle formation", including appressoria, substomatal

esicles and infection hyphae, was obtained with Puccinia coronata under the proper conditions. These structures formed on artificial media appeared identical to those which have been described in host tissue. At least three factors were shown to be involved in vesicle formation, pH, zinc, and a "gelatin factor". The latter could be extracted from gelatin by dialysis. The required pH range was 6.2 to 6.6 and the optimum zinc concentration for vesicle formation was 9-14 ppm. The same factors were required for a characteristic type of germ tube branching. Branching occurred under the same general conditions as vesicle formation but over a wider range of both pH and zinc concentration.

Zinc could not be replaced by any other metal and the gelatin factor could not be replaced with a number of amino acids, growth factors, and nucleic acid derivatives which were tested.

Preliminary tests on water agar with added zinc and silicon gave both branching and vesicle formation indicating that silicon may be the gelatin factor. Silicon stimulated vesicle formation and branching at low concentrations and inhibited the same processes at higher concentrations. There appeared to be a complex interaction between zinc and silicon.

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### GENETIC ASPECTS OF THE PRODUCTION REGISTRY PROGRAM OF THE UNITED DUROC RECORD ASSOCIATION[1]

CHARLES EDWIN SHELBY[2]
Departments of Animal Husbandry and Genetics

The main objectives of this study were to measure the relative influence of heredity and environment on the three measures of sow productivity stressed in the Production Registry program conducted by the swine breed associations, and to suggest any changes in the present program which might increase the accuracy of selection.

The data were obtained from the United Duroc Record Association, Peoria, Illinois. They consist of the records of 869 litters from 31 herds in 1949 and of 691

litters from 30 herds in 1950. These data were from the herds which completed all requirements in the Official Duroc Production Tested Herd Program in either or both years. They include complete records on all sows in these herds in 1949 and in 1950. The data for each year were analyzed separately.

Means and standard deviations were slightly higher in 1949 than in 1950. Coefficients of variation were almost identical in both years.

Means, Standard Deviations and Coefficients of Variations
in 1949 and in 1950

| S.V. | 1949 | | | 1950 | | |
|------|------|-----|------|------|-----|------|
| | Mean | s | C.V. | Mean | s | C.V. |
| 1. Number of pigs at birth | 10.18 | 2.80 | 28 | 10.26 | 2.83 | 28 |
| 2. Number of pigs at weaning | 7.18 | 2.30 | 32 | 7.61 | 2.50 | 33 |
| 3. Weight of the litter at weaning | 237.5 | 100.3 | 42 | 255.7 | 103.8 | 41 |

Phenotypic correlations were similar in 1949 and 1950. Correlations between size and weight of the litter at weaning were largest.

Phenotypic Correlations in 1949 and in 1950

|  | Year | |
|---|---|---|
| Correlation | 1949 | 1950 |
| $r_{N_0 N_{56}}$ | 0.49 | 0.55 |
| $r_{N_0 W_{56}}$ | 0.37 | 0.43 |
| $r_{N_{56} W_{56}}$ | 0.81 | 0.79 |

Differences between herds were the most important of the three sources of

environmental variance at weaning. They were statistically highly significant for all characters. Differences in age of dam were the most important source of variance at birth. They were statistically highly significant for litter size at birth and for litter weight at weaning. Differences between litters farrowed in the spring and in the fall were not important.

The standard deviation of weaning weight was less for litters from gilts than from older sows. The actual values increased almost but not quite in proportion to the mean. This suggests that the most perfect age correction factor should be partly additive and partly multiplicative.

Per Cent of the Total Variance Due to Environmental
Influences in 1949 and in 1950

| Influence | Number of pigs at birth | | Number of pigs at weaning | | Weight of the litter at weaning | |
|---|---|---|---|---|---|---|
|  | 1949 | 1950 | 1949 | 1950 | 1949 | 1950 |
| Herd | + 5.0 | + 6.1 | +17.9 | "10.0 | +48.3 | +28.2 |
| Season | - 0.2 | - 0.3 | + 0.4 | + 0.2 | + 0.4 | + 0.0 |
| Age of dam | +13.9 | + 6.6 | + 2.2 | + 0.4 | + 9.6 | + 5.9 |
| Total | +18.7 | +12.4 | +20.5 | +10.6 | +58.3 | +34.1 |

Means, Standard Deviations, and Coefficients of Variation
of Weaning Weight at Three Ages in 1949 and in 1950

| Months | 1949 | | | 1950 | | |
|---|---|---|---|---|---|---|
|  | Mean | s | C.V. | Mean | s | C.V. |
| 12 | 214.8 | 89.4 | 42 | 221.2 | 91.5 | 41 |
| 18 | 241.6 | 104.3 | 43 | 254.9 | 96.4 | 38 |
| 24 or over | 259.9 | 103.0 | 40 | 299.9 | 108.0 | 36 |
| Total | 237.5 | 100.3 | 42 | 255.7 | 103.8 | 41 |

Heritability and Repeatability in 1949 and in 1950

|  | Heritability Half sib | | Heritability Full sib | | Repeatability | |
|---|---|---|---|---|---|---|
|  | 1949 | 1950 | 1949 | 1950 | 1949 | 1950 |
| 1. Number of pigs at birth | .084 | .537 | .254 | .187 | .215 | .279 |
| 2. Number of pigs at weaning | .066 | .282 | .003 | .113 | .134 | .184 |
| 3. Weight of the litter at weaning | .150 | .231 | .097 | .325 | .137 | -.003 |

Linear and quadratic regressions of litter size at birth on age of dam from 0 to 16 months were fitted in both 1949 and 1950. The regressions indicate that the increase in litter size at this age is curvilinear. The linear regression was 0.23 pig per month of age in 1949 and 1.12 in 1950.

Correction factors for age of dam were computed at one and two month intervals in the period from 10 to 20 months, and at 6 month intervals thereafter. The correction factors for 1949 and for 1950 were similar. They may be used to make comparable records from sows of different ages.

Intraherd heritability and repeatability were estimated for these characteristics. The estimates of heritability which were subject to large sampling errors differed

greatly in the two years. The estimates for repeatability seemed more reliable. The size of these estimates indicate that improvement by means of simple mass selection will be slow.

The efficiency of selection in the Official Duroc Production Tested Herd Program can be increased:

a) by the use of repeated observations; (Genetic progress will be about 30 per cent greater when selection of breeding stock is based on two litters instead of one.)

b) by using deviations from the herd average as a measure of individual merit;

c) by basing selection on records corrected for age of dam;

d) by considering the average performance of close relatives when individual merit is close.

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# SOME STUDIES ON THE DIFFUSION OF SODIUM IN SODIUM TUNGSTEN BRONZE[1]

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Department of Chemistry

This investigation was undertaken to study the process of sodium diffusion in single crystals of the metallic sodium tungsten bronze. Concentration gradients were established by effusion of sodium from single crystals into a vacuum. The concentration gradients were measured by means of an x-ray determination of a precision lattice constant, subsequently making use of the Vegard's law relationship to evaluate the sodium concentration. Advantage was taken of the high absorption of copper x-radiation in the sodium tungsten bronze in order to measure the lattice parameter of an exposed crystal surface.

The diffusivity was evaluated by a method which to the author's knowledge has not been previously suggested or used. This method was based upon Fick's first law rather than his second. The data obtained from a series of crystals held at

constant temperature for varying times gave a family of curves showing the concentration as a function of depth with time as a parameter. From these curves the mass of sodium transferred through a plane parallel to the surface and at any particular depth was plotted as a function of time. The slope of this curve divided by the concentration gradient, both evaluated at the same time and depth, was the diffusivity for the corresponding concentration.

Three such series of crystals were run: one each at $664°C.$, $752°C.$, and $832°C.$ Diffusivities were evaluated for a bronze formula of $Na_{0.78}WO_3$. The evaluated diffusivities were fit to an Arrhenius type equation:

$$D = D_0 \exp\left(-\Delta H/RT\right) \qquad (1)$$
$$D_0 = 0.87 \text{ cm}^2/\text{sec}$$
$$\Delta H = 51.8 \text{ kcal/mol} .$$

In conjunction with the diffusion studies it was necessary to determine the coefficients of linear expansion. For $Na_{0.8}WO_3$ the following expansion formula is valid:

$$L = L_0(1 + 8.81 \times 10^{-6}T - 1.92 \times 10^{-9}T^2) . \quad (2)$$

In this equation L is any linear length and T is the temperature in $°C.$

## ROLE OF ADENINE THIOMETHYLRIBOSIDE IN YEAST METABOLISM[1]

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Although the sulfur-containing nucleoside, adenine thiomethylriboside, was isolated from yeast 40 years ago, its phsyiological function has remained obscure. The present investigation has been a study of the anabolism of the compound and its significance to the cell.

The first requirement for such an investigation was the development of a suitable method of analysis. A colorimetric test with nitroprusside similar to that used for methionine assay was developed which permitted the determination of the nucleoside in the absence of methionine. To separate the nucleoside from the amino acid, the former was precipitated as the phosphotungstate while the methionine remained in solution. The time-consuming and inefficient method formerly in use for the isolation of adenine thiomethylriboside from yeast has been greatly simplified. Much better yields can now be obtained within a relatively short time.

The biosynthesis of adenine thiomethylriboside by either Saccharomyces cerevisiae or Torulopsis utilis was discovered to be dependent on the presence of methionine in the growth medium of the yeast. An excess of this amino acid did not affect the growth of the microorganisms although it was essential for the accumulation of the riboside. Furthermore, a direct correlation was shown between the amount of adenine thiomethylriboside produced by yeasts and the quantities of

methionine present in the medium. The optimal level of methionine in the growth medium was found to be 0.05 per cent. This concentration of methionine caused the concentration of the nucleoside to be as high as 0.6 per cent of the dry weight of the cell.

Methionine in this case is not fulfilling a non-specific function such as serving as a source of sulfur since other sulfur compounds, both organic and inorganic, are unable to replace methionine. More conclusive proof came from experiments with radioactive sulfur which had been administered as methionine and was recovered in the nucleoside with no decrease in its specific activity.

Studies with $C^{14}$-labeled methionine demonstrated that its alpha, beta, and gamma carbons are not transposed to the adenine thiomethylriboside. This indicates that the fragment transposed cannot be larger than -SCH₃; however, mercaptan does not serve as a precursor. Therefore, it was proposed that methionine and adenosine are condensed to form a sulfonium compound which is the actual transmethylating form of methionine. Splitting of this compound leads to the formation of adenine thiomethylriboside.

An investigation of the adenine thiomethylriboside content of microorganisms showed that the compound is found in other yeasts, bacteria, and molds. Failure to detect the nucleoside in a particular species does not exclude the possibility that the organism makes use of the proposed transmethylation route, but does not accumulate adenine thiomethylriboside in sufficient amounts for detection. The thetin-like structure of the intermediary methionyladenosine suggests an ubiquitous cellular function.

## EFFECTS OF FOUR CROP ROTATIONS ON SOIL FUNGI AND CORN ROOT NECROSIS[1]

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The cause of corn root necrosis has been investigated for many years, but there is little information about the effects of crop rotation on its abundance or on types and distributions of soil fungi associated with corn roots.

Sterilized oat straws were buried next to and 18 to 20 inches away from hills of corn in the field at planting time. These straws were buried in two experimental corn-oats, corn-oats-meadow, corn-oats-meadow-meadow and corn-corn-oats-meadow rotations; one located on the Soil Conservation Experimental Farm, Clarinda, Iowa, and the other on the Howard County Experimental Farm, Cresco, Iowa.

Corn root systems were removed, thoroughly washed and examined on the thirtieth day of June, July, August, and September at Clarinda and on the fourteenth day of July, August, September, and October at Cresco. Observations revealed the least amount of root necrosis on the corn roots grown in the corn-oats-meadow rotations, followed closely by those in the corn-oats-meadow - meadow rotations; there was somewhat more root necrosis in the corn-corn-oats-meadow rotations, with most in the corn-oats rotations. In general, root necrosis increased in abundance as the season advanced.

At each time of corn root removal, some buried oat straws were also taken. The fungus-colonized straws and necrotic portions and healthy portions of corn roots, when plated on agar, revealed fifty-five genera of fungi; generically unidentified representatives of Actinomycetes, Basidiomycetes, and Myxobacteriales, plus a great number of nematodes and a number of bacteria which were not recorded.

Fusarium spp., Sporotrichum sp., Pyrenochaeta sp., sphaerosporangiate Pythium spp. and Phytophthora spp., Trichoderma spp. and Alternaria spp. were the six most prevalent genera of fungi at both locations. In addition to the first six genera of fungi, a nematosporangiate Pythium sp., Phoma sp., Myrothecium sp., a chla-

mydospore producing fungus and Periconia sp. were among the first fifteen most prevalent genera and types of fungi at both locations.

Phoma sp., a chlamydospore producing fungus, Pythium acanthicum, Chaetomium sp., Stachybotrys sp. and Rhizopus spp. were cultured primarily from straws, and Fusarium spp., Sporotrichum sp., spaerosporangiate Pythium spp. and Phytophthora spp., Trichoderma spp., Alternaria spp., Myrothecium spp., a black sclerotium-producing fungus, Curvularia spp., Penicillium spp., Helminthosporium spp., Cephalosporium sp., Aspergillus sp., Verticillium sp. and Rhizoctonia sp. were cultured both from roots and straws. All these had been found to be "soil inhabitants" by a similar method in a previous laboratory experiment. Pyrenochaeta sp., a nematosporangiate Pythium sp., Periconia sp., an orange sclerotium-producing fungus, Myxotrichella sp. and Fusarium moniliforme, which were cultured primarily or solely from roots in 1952, had not been cultured from straws in the previous experiment.

Fusarium spp. and Penicillium spp. were recovered with approximately equal frequencies in the four rotations, while Stemphylium sp. appeared more abundantly in the corn-oats-meadow than in the other rotations at both locations. Twelve additional genera and types of fungi exhibited similar colonization patterns in the four rotations at the two locations. Nematosporangiate Pythium sp., Trichoderma spp., Pythium acanthicum and Curvularia spp. exhibited somewhat different colonization patterns with respect to rotations at the two locations.

In general, the effects on the amount of corn root necrosis attributable to the corn-oats-meadow, corn-oats, meadow-meadow, corn-corn-oats-meadow and corn-oats rotations were not observed to be associated with the abundance or lack of occurrence of individual genera or types of fungi.

The pathogenicity of 478 isolates of various cultured fungi was determined against corn seedlings and corn seedling roots. All the isolates of nematosporangiate Pythium sp., Phytophthora sp. (strain "A") and Phytophthora sp. (strain "B") proved to be pathogenic to corn roots. A limited number of sphaerosporangiate Pythium

spp. were pathogenic to corn roots. A fee isolates of Pyrenochaeta sp., Periconia sp., Fusarium sp., and orange sclerotium-producing fungus, Alternaria spp., Trichoderma spp. and Myxotrichella sp. caused observable necrosis on corn roots. Other isolates causing observable necrosis, i.e., Cephalosporium sp., Circinella sp., Curvularia spp., were considered of minor importance in respect to their occurrence.

It is of interest to note that Diplodia zeae a suspected corn root pathogen, and Phialophora radicicola, a known corn root pathogen, were neither seen on nor isolated

from corn roots or oat straws. A nematosporangiate Pythium sp. and Pyrenochaeta sp., both pathogenic to roots, were found to colonize primarily corn roots, rarely straws. For the first time Phytophthora spp. and Periconia sp. were observed to be pathogenic to roots of corn; the latter fungus was cultured solely from roots.

This investigation suggests that Pythium paroecandrum, P. debaryanum, Phytophthora spp. (strains "A" and "B"), Pyrenochaeta sp. or Periconia sp. in addition to or rather than a nematosporangiate Pythium sp. may be the initial cause of corn root necrosis.

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## A THEORY OF SAMPLING FINITE UNIVERSES WITH ARBITRARY PROBABILITIES[1]

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Department of Statistics

Among the decisions involved in designing many surveys is that of specifying the method by which the sample is to be selected and the estimation to be carried out. From N unit, n are to be selected, determinations are to be made on the n units, and inferences are to be drawn about characteristics of the N units. In the early applications of probability sampling in survey work, equal probability of including each of the N units in the sample was specified. In recent years, however, it has been recognized that unequal probabilities of selection for the N units, under certain circumstances, could materially improve the precision of results.

A theory of sampling systems (including both the method of selection and the method of estimation) is developed in this dissertation for the case of sampling a finite universe without replacement. The principal characteristic of this theory is that the estimators and the moments of their sampling distributions are expressed in terms of the probability of inclusion in the sample of k-tuplets of the universe units. The theory is developed includes many of the known results for the equal probability selection method as special cases.

The successful employment of the sam-

1 a. Chairman of Committee, P. C. Tang, Dept. of Statistics.
   b. Doctoral Thesis No. 1316. Submitted July 15, 1952.
2 a. B.A. St. Olaf College, Northfield, Minnesota, 1941.
   M.A. University of Minnesota, Minneapolis, Minn., 1947.
   b. Associate, Agricultural Experiment Station.

pling systems set forth depends upon the availability of prior quantitative information on the units comprising the universe of investigation. In many situations this information can be used advantageously in a variety of ways in designing the sampling investigation. As a basis for comparing the use of auxiliary information to vary the inclusion probabilities with alternative uses, an extensive review of the literature relating to these alternative techniques was undertaken under the headings, (1) restrictions on the selection of the sample, (2) definition of the sampling units, (3) methods of estimation, and (4) variable selection probabilities. This presentation emphasized the distinctions among the four types of uses.

The theoretical portion of the dissertation develops, from first principles, a general class of estimators, The elements of this class are linear functions of the variate under estimate with coefficients depending upon the universe units included in the sample. These coefficients can be determined by imposing the condition of unbiasedness on the estimator. The simplest case considered yields an estimator of a total for some characteristic x of the form

$$\hat{X} = \sum_{i=1}^{n} x_i / P_i',$$

where $P_i$ is the a priori probability of including the i-th universe unit (i=1, 2, ..., N) in a sample of size n and $z_i$ is the value of the characteristic x for the i-th unit selected for the sample. This estimator is unbiased. Its variance and estimated vari-

ance are given and depend only on the $x_i$, $p_i$, and $P_{ij}$, where $P_{ij}$ is the a priori probability of including both the units $u_i$ and $u_j (i, j=1, 2, \ldots, N; i \neq j)$ in a sample of size n.

The preceding case is extended to two stages of sampling with unequal probabilities of selection for the sampling units at both stages. The comparable unbiased estimator for this situation is of the form

$$\hat{X} = \sum_{i=1}^{m} ( \sum_{j=1}^{n_i} x_{ij}/P_i' P_{j/i}')$$

Here $P_i$ is the inclusion probability for the i-th first-stage sampling unit (i=1, 2, ..., M) and $P_{j/i}$ is the a priori probability that the j-th second-stage unit (j=1, 2, ..., $N_i$) will be included in a sample of $n_i$ such units given that the i-th first-stage unit is selected at the first stage. The variance of this estimator is derived, and unbiased estimates of the contributions to the variance attributable to each stage of the sampling are presented. Several well known results for both equal and unequal probability selection are obtained as special cases of this formulation. Biased estimators and their mean-square errors are also considered.

Methods of selecting samples with probability proportionate to a measure of size for each of the sampling units have been in use for a number of years. Several of these methods were examined and were found to be unsatisfactory for use in applications of the theory of this work. Several new methods of selecting samples with probability proportionate to an arbitrary measure were proposed. These methods were shown to give each pair of the universe units an a priori nonzero probability of inclusion in the sample. This property is required of any sampling plan permitting unbiased estimation of sampling variance. The methods developed do not require unduly arduous calculation, and they are proposed as particularly suitable for the selection of two first-stage units per stratum in a stratified multi-stage sampling design.

An examination was made of the conditions under which unequal inclusion probabilities for first-stage units, assigned on the basis of an auxiliary variate in a stratified two-stage plan, could lead to gains in efficiency over equal probability selection. Possible gains were shown to depend upon the existence of an average within stratum positive correlation between the variate under measurement and the square of the auxiliary variate.

When a sampling investigation is designed to provide estimates of means or totals of one (or a few related) characteristics, the use of the sampling systems of the type developed in this work may prove to be of particular importance. When the auxiliary information is highly positively correlated with the variate under measurement, sampling two or more units with probability proportionate to the auxiliary variates at each stage, in a stratified multi-stage design, makes full use of the auxiliary information. It further provides estimation procedures which are measurable in the sense that unbiased estimates of sampling variance can be made without resorting to additional assumptions. In multi-variate investigations the use of the auxiliary information through stratification, sampling unit equalization and ratio or regression methods of estimation, with equal probability selection, seems preferable. These devices incorporate the auxiliary information in both the design and analysis, and, in general, they lead to computationally simpler methods of estimation and subsequent analysis, an important consideration in multi-variate investigations.

In situations where unequal inclusion probabilities for the individual units arise naturally through the selection process, and in examination of related problems (such as those occasioned by the failure of designated respondents to be "at home" when called upon by an interviewer), the basic approach of the theoretical portions of this investigation is of particular interest and may be expected to lead to new results.

## COMBINING ABILITY OF HOMOZYGOUS DIPLOIDS OF CORN RELATIVE TO LINES DERIVED BY INBREEDING[1]

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Homozygous diploid lines of corn produced by the monoploid method were evaluated for combining ability. This evaluation was necessary to provide a preliminary appraisal of the monoploid method, a new technique in corn breeding. The monoploid method, developed by Dr. S. S. Chase, is a procedure by which spontaneously occurring monoploid plants are identified in the seedling stage with the aid of a genetic marker system. Many of the monoploid plants are able to live to maturity and produce normal pollen and eggs. The successful self pollination of these monoploids gives homozygous diploid progeny. The objective of this research was to evaluate the combining ability of homozygous diploids and to determine if the ability to live in the monoploid state had any relation to the combining ability of the derived lines.

Homozygous diploids were evaluated from two populations, Golden Cross Bantam and Stiff Stalk Synthetic. All items tested, including the sweet corn material were top crosses with the dent single cross tester, L289 x 1205.

In the Golden Cross Bantam population 23 homozygous diploids were compared with 37 random $S_1$ lines in 1950. Comparative mean yields were 61.8 and 62.2 bushels per acre, respectively. These yields were not significantly different. Graphs of the frequency distributions of the two groups were very similar.

In the Stiff Stalk Synthetic populations 31 homozygous diploids were compared with 35 unselected $S_5$ lines and with five selected lines in 1951. Mean yields were 58.4, 58.1, and 60.1 bushels per acre, respectively. Most of the same lines plus several additional ones were tested in 1952. Then, 43 homozygous diploids were compared with 38 unselected $S_5$ lines and with five selected lines. Mean yields were 103.8, 103.8, and 99.5 bushels per acre, respectively. Differences each year between the homozygous dip-

loids and unselected inbreds were not significant, nor were the differences between the selected inbreds and the other two groups significantly different either year. Graphs of the frequency distributions of the homozygous diploids and unselected inbreds were very similar in each of the two years.

From the one year's data from Golden Cross Bantam and the two years' data from the Stiff Stalk Synthetic population, it was concluded that the combining ability of a random group of homozygous diploids was little, if any, different from the combining ability of a random group of unselected inbred lines, at least for the populations studied. This indicated that monoploid livability had little if any influence on the combining ability of the resulting homozygous diploid progeny. It was pointed out that similar studies on other populations were necessary to validate the above conclusions.

In the 1950 yield trial several single crosses of monoploid plants crossed to the tester were included. These single crosses gave significantly greater yields than the homozygous diploids from the same population, Golden Cross Bantam. A yield test the following year, using remnant seed of these items, gave similar results. Since a biological explanation of this relationship was not evident, it was concluded that this significance was probably due to the chance of sampling.

Two comparisons were made in the 1950 test comparing the yields of inbreds with the yields of homozygous diploids extracted from those inbred lines. The inbred P51 yielded 59.4 bushels per acre, whereas the homozygous diploid from P51 yielded 61.6 bushels per acre. The inbred W22 and the homozygous diploid from W22 gave yields of 84.0 and 87.2 bushels per acre, respectively. These results were not unexpected.

From the various theoretical aspects considered, it was concluded that a group of homozygous diploids would have the same gametic distribution as a zygotic population; therefore, a top cross test of homozygous diploids and open pollinated plants would give similar results. Homozygous diploids would be expected to be free of lethals; however, in the limits of inbreeding an inbred population would be expected to be free of lethals also.

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Consideration was also given compara-
tive frequencies of zygotes and gametes
of a given yield potential. Means and
variances of zygotic and homozygous dip-

loid distributions were also calculated.
From the theoretical aspects considered,
no advantages were apparent for the
yielding ability of a group of homozygous
diploids.

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## SERUM PROTEINS, LEUKOCYTES, AND MORTALITY OF SEVEN INBRED MOUSE STRAINS DURING CORTISONE ADMINISTRATION AND INFECTION WITH SALMONELLA TYPHIMURIUM[1]

### SARANE THOMPSON[2]
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The purpose of this investigation was
to determine the relationship between
the serum proteins and natural resist-
ance to mouse typhoid. The seven in-
bred mouse strains used in this study
were chosen for their wide range in nat-
ural resistance to Salmonella typhimuri-
um. Electrophoretic analyses were made
of the sera of both normal and infected
mice to determine whether strain differ-
ences in the serum protein composition
were correlated with resistance. Addi-
tional data on plasma volume, body weight,
spleen weight, and number of circulating
leukocytes were utilized to evaluate the
physiological significance of the serum
protein changes.

Certain observations suggested that
adrenal hormones might contribute to the
pathological alterations and might even
be a basis for natural resistance. In a
study of these same mouse strains, oth-
er investigators established that resist-
ance to Salmonella typhimurium was
associated with high leukocyte counts.
Increased excretions of 17-ketosteroids,
depletion of adrenal ascorbic acid, hy-
perglycemia, lymphopenia, eosinopenia
and neutrophilia are all known to be char-
acteristic of both gluco-corticoid admin-
istration and Salmonella infections. For
this reason, the investigation was de-
signed to compare the responses of re-
sistant and susceptible mice both to cor-
tisone and to mouse typhoid. The data
warranted the following conclusions:

1. Certain characteristics of mouse
typhoid infection which had been described

in earlier investigations were confirmed
in this study. In the first week of in-
fection, the circulating neutrophils in-
creased, the erythrocytes and lympho-
cytes decreased, and the eosinophils
disappeared from the blood. The spleen
tripled in weight. By the second week of
the infection, agglutinins specific for S.
typhimurium were present in the blood.

2. A study was made of certain patho-
logical changes which had not been previ-
ously described. The blood volume often
increased; the relative erythrocyte vol-
ume decreased during the infection. As
a result, the plasma volume increased
up to 20 per cent in some strains. Plasma
fibrinogen and the alpha and beta globulins
increased in concentration while the al-
bumin decreased. Due to the increased
plasma volume, these relationships were
valid whether the proteins were expressed
as grams per cent of serum or as grams
in total plasma. Because the urine pro-
tein tests were negative and because the
plasma fibrinogen increased, it was con-
cluded that the decline in serum albumin
could not be attributed to either liver or
kidney damage.

3. Significant time relationships were
established. The increase in the alpha and
beta globulins was maximum at the time
of the greatest dissolution of lymphatic
tissue, as estimated by the decrease in
the circulating lymphocytes.

4. The gamma globulins did not increase
until the second week of infection. Elec-
trophoretic analyses of sera before and
after their incubation with the cellular
antigen indicated that the gamma globu-
lins consisted, for the most part, of spe-
cific agglutinins to S. typhimurium.

5. Strain differences were observed in
the electrophoretic patterns and total pro-
tein concentrations of normal serum, in
the normal body weights and packed eryth-
rocyte volumes of whole blood, and in both
the initial weights of the spleen and the

rates of spleen enlargement in infection. None of these differences were associated with innate resistance to S. typhimurium.

6. Other strain differences in response to infection were found to be correlated with natural resistance. Anemia, lymphopenia, loss of body weight, decrease in serum albumin, and increase in the alpha and beta globulins were most extreme in the susceptible mice. In respect to all these traits, the seven strains were almost identically ranked in resistance and in the magnitude of the response.

7. The responses of the neutrophils, agglutinins and gamma globulins were also found to be greater in susceptible mice. Because these three responses are known to be protective mechanisms, it is possible that all the traits listed above were correlated with resistance because they were the results, not the causes, of innate immunity.

8. The most significant clue to the basis for natural resistance was the correlation of low lymphocyte count with low innate resistance in uninfected mice - a relationship which had previously been established in these strains by other workers. This correlation was confirmed in the present study although the method of bleeding was designed to put a minimum of stress upon the mice. This fact damages the hypothesis that low lymphocyte counts (and low natural resistance) were a result of increased adrenal secretion.

9. Although there was insufficient evidence to implicate the adrenals as a basis for the differential resistance of these seven strains, there was evidence that the adrenals had an expression in mouse typhoid pathology: (1) Cortisone administration altered the protein composition of serum. It accentulated the

strain differences in electrophoretic patterns which appeared during mouse typhoid. (2) Cortisone lowered the resistance of all mice to S. typhimurium. It was effective in dosages which were neither unphysiological nor toxic. Massive doses of two other steroid hormones, progesterone and desoxycorticosterone, did not decrease natural resistance. It was concluded that the harmful action of cortisone could not be attributed to the general effects of hormone over-dosage. (3) The cortisone dose which caused the most resistant mice to have the mortality curve characteristic of susceptible mice also caused them to have a similar serum protein composition and lymphocyte count during mouse typhoid.

10. Pretreatment with cortisone was most effective in lowering natural resistance when administered two days before the typhoid inoculation. It was established that when mice were pretreated in this way, their leukocyte pictures were characterized by lymphopenia and neutrophilia. It was concluded that the lymphocyte was of greater importance in establishing natural immunity than was the neutrophil.

11. Cortisone had a differential effect on the survival of immune and normal mice which were infected by identical bacterial inoculations. A hormone dose which reduced the survival of normal resistant mice from 100 per cent to 0 per cent had no significant effect on immune mice.

12. Cortisone increased the concentration of total protein in serum. Because hematocrit values were not significantly altered, it was concluded that this hyperproteinemia could not have been the result of hemoconcentration.

## EARLY EVALUATION OF POTATO SEEDLINGS IN BREEDING
FOR RESISTANCE TO LATENT MOSAIC[1]

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and Department of Horticulture

This study was undertaken to determine if an efficient means could be developed for detecting susceptible plants in a potato progeny segregating for immunity to the latent mosaic (virus X).

Susceptible seedling potatoes, when inoculated with a suitable strain of potato virus X, expressed local necrotic symptoms within four days. Most susceptible potato plants, vegetatively propagated, expressed necrotic symptoms five to fifteen days after inoculation with virus X.

The optimum temperature for symptom expression of virus X in potatoes was found to be about 16°C., but symptoms were expressed over a range of 10° to 24°C. when suitable isolates were used.

The number of susceptible potato seedlings that expressed symptoms after being inoculated with virus X was increased when the light intensity under normal winter greenhouse conditions was decreased approximately 300 foot candles.

Mass inoculation of potato seedlings was effectively carried out using a paint spray gun with 12 g. of 400 mesh carborundum suspended in 100 ml. of inoculum. Application at 15 lb./in.$^2$ pressure with a plant to nozzle distance of one cm. caused no apparent mechanical injury. Less than six per cent of the susceptible plants in a segregating progeny escaped infection when this technique was used.

Ten isolates of virus X varying from mild to severe in their reactions on several hosts were separated using Gomphrena globosa L. as the local lesion host. These isolates were compared in effectiveness of inciting symptoms in susceptible potato plants. X 5 isolated from a potato selection grown in Maine incited local and systemic symptoms in the greatest number of plants and over the greatest temperature range. Local symptoms were incited equally well by isolate X RS obtained from the University of Wisconsin. However, the number of susceptible plants that expressed systemic symptoms was significantly less than with isolate X 5. Another, isolate X 8, obtained from a Green Mountain potato grown at North Dakota was the mildest in reaction on potatoes. Following inoculation, isolate X 8 was demonstrated present in Datura stramonium L., Nicotiana glutinosa L., N. rustica L. and N. tabacum L. at 16° and 24°C., but no symptoms developed. Isolate X 8 readily incited local symptoms when inoculated to G. globosa.

Mechanical inoculation using a suitable isolate of virus X was compared with the conventional graft test for immunity and was found to be equally reliable. All susceptible X-free potato plants tested, whether they were from susceptible parents or from immune parents, expressed necrotic symptoms after being inoculated with a severe isolate of virus X.

A virtually virus X immune seedling crop of potatoes was obtained by mass inoculation of seedling plants before transplanting to the greenhouse bench and by a second hand inoculation after the plants had become established.

## MAGNETIC STUDIES OF NICKEL COMPLEXES WITH SOME VIC-DIOXIMES[1]

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A number of vic-dioximes have been used as reagents in the quantitative analysis of nickel and palladium, including α-benzildioxime, 2,3-butanedionedioxime (dimethylglyoxime), 1,2-cycloheptane dionedioxime, 1,2-cyclohexanedionedioxime, and α-furildioxime. None of these can be regarded as the completely satisfactory reagent for this purpose. Differences in physical properties exist, also, between the nickel(II) complexes of the several vic-dioximes; these differences are somewhat surprising since the reactions in which the complexes are formed have been considered to be identical.

Studies of the fundamental character of the vic-dioximes and their nickel complexes are indicated in order to find explanations for the physical differences, and also to provide information useful for possible future improvement of these reagents.

Magnetic susceptibility measurements are often of value in the study of complex compounds of the elements of the first transition series, since they allow the determination of the number of unpaired electrons present. In order that such measurements might be made on the nickel(II) complexes of the vic-dioximes and that such equipment would be available for other investigations of a similar nature, an apparatus suitable for obtaining these data was assembled.

The Gouy method of susceptibility determination was employed as the basis for the design and operation of the equipment, this technique being simpler, more versatile and more accurate than other methods that were considered. The construction, calibration and operation of the apparatus are described in detail. An electromagnet, its power supply, a semi-micro balance, a sample tube suspension, and a current-measuring device comprise the major units of the equipment. The calibration scheme and method of operation adopted are believed to allow susceptibility measurements on liquid samples to be made with a precision of 0.1

per cent or better and an accuracy of the same order of magnitude.

The water-insoluble nickel(II) complexes of α-benzildioxime, 2,3-butanedionedioxime, α-furildioxime, 1,2-cycloheptanedionedioxime and 1,2-cyclohexanedionedioxime were prepared in fairly large amounts by adaption of the analytical procedures in which these reagents are usually used. To facilitate working with the nickel compounds, they were all recrystallized from organic solvents, being transformed in this process from amorphous powders to more easily handled needlelike crystals.

The magnetic susceptibilities of the crystalline complexes were measured. They were found, without exception, to be diamagnetic, and thus are to be considered as normal nickel(II) complexes of the square coplanar type, at least in the solid state. The susceptibility data obtained for the nickel compounds of the first two of the reagents named above correspond fairly well to figures previously reported in the literature for the same compounds.

Magnetic and allied spectrophotometric studies were carried out on solutions of the same five nickel(II) complexes, in both reactive and nonreactive solvents. The complexes dissolved unchanged in chloroform and o-dichlorobenzene. When they were dissolved in pyridine or n-butylamine, however, greater or lesser amounts of reaction took place with the solvents, depending on the particular complex observed. The reaction resulted in the production of a paramagnetic species of nickel complex and also served to diminish the height of an absorption band usually attributed to the diamagnetic square type of compound; it therefore could be followed magnetically or spectrophotometrically.

These studies established definitely the fact that 1,2-bis(α-furildioximo-N, N') nickel(II) is the least stable of these compounds toward reaction with pyridine or n-butylamine to form an unknown paramagnetic complex. The results of the observations on pyridine and n-butylamine solutions of the other four compounds are not entirely in agreement, but they indicate that 1,2-bis(α-benzildioxime-N, N')nickel(II) is the bext least stable.

Some tentative suggestions are made as

⟩ the nature of the reactions of 1,2-bis
⟨:-furildioximo-N, N')nickel(II) with pyri-
ⱨine and n-butylamine, on the basis of
ⱨagnetic susceptibility and conductance
ⱨeasurements made on solutions of the
romplex in these two solvents. The ad-

dition of two molecules of the basic sol-
vent to the original square complex to
form an octahedral paramagnetic config-
uration, followed by more or less ioniza-
tion, is regarded as the most probable
course for these reactions to take.

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# EFFECT OF PROTEIN MATERIALS UPON THE GROWTH PROMOTING ACTIVITY OF VITAMIN B₁₂ FOR LACTOBACILLUS LEICHMANNII₁

ERMA MILDRED SCHUMACHER VAN DER ZANT₂
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⟩ In the microbiological assay of vitamin
$B_{12}$ with Lactobacillus leichmannii two
ⱨactors complicate the results. First,
ⱨitamin $B_{12}$ is not a specific nutrient for
⁚. leichmannii. Secondly, vitamin $B_{12}$
ⱨccurring in tissues is bound to proteins
ⱨhich must be heated, subjected to pro-
eolysis, or treated with cyanide to make
ⱨitamin $B_{12}$ available for use by this or-
ⱨanism. In these process'es, however,
ⱨrowth promoting substances, purine and
ⱨyrimidine derivatives and peptides which
ⱨubstitute for vitamin $B_{12}$, are released.
ⱨnhibition of vitamin $B_{12}$ by protein binding
ⱨnd the presence of growth factors in the
ⱨest materials cause opposing effects. A
ⱨpecial case of vitamin $B_{12}$-inhibition oc-
ⱨurs with extracts of gastric mucosa which
ⱨontain a substance that prevents the ab-
ⱨsorption of vitamin $B_{12}$ by bacteria thus
ⱨnhibiting their growth. It was the pur-
ⱨose of this investigation to study the ef-
ⱨects of several protein materials upon the
ⱨrowth of L. leichmannii in order to deter-
ⱨmine the nature of the vitamin $B_{12}$-binding
ⱨubstances and to fractionate and concen-
ⱨrate the vitamin $B_{12}$-inhibitory substances
ⱨrom proteins.

For testing inhibition L. leichmannii was
ⱨrown on a standard assay medium con-
ⱨaining amino acids, salts, vitamins, glu-
ⱨose, and other nutrients. The medium
ⱨas heated with vitamin $B_{12}$ by autoclaving
ⱨor five minutes at 15 pounds pressure.
ⱨest samples were then added and the tubes
ⱨnoculated, incubated for 22 hours, and
ⱨurbidity read in a photometer.

A commercial preparation of dessicated
hog gastric mucosa (Ventriculin) was ex-
tracted with water and treated with protein
precipitants to obtain fractions containing
the vitamin $B_{12}$-inhibitory principle. Am-
monium sulfate, ethanol, or a combination
of the two methods at different pH values
were used as precipitating agents. A zinc-
ethanol method was found to be satisfactory
also. All of these methods gave concen-
trates of inhibitory principle separated
from a portion of the inactive material.
However, these concentrates contained
growth factors which replaced vitamin $B_{12}$
for L. leichmannii. Although these sub-
stances complicated the assay of the inhi-
bitory principle, they could be diluted out
in high concentrations of the latter.

A great deal of effort was expended in
trying to separate the growth factors from
the vitamin $B_{12}$-inhibitory principle. No
precipitating agent not any of the conditions
used gave a concentrate of vitamin $B_{12}$-
inhibitor free of growth substances. Dia-
lysis removed a portion of the growth sub-
stances but not enough to prevent interfer-
ence in the assay

The use of chromatography and ion ex-
change as purification processes was in-
vestigated. By using ascending chromato-
graphy on paper with concentrated sodium
citrate as developing agent, inactive sub-
stances, colored by ninhydrin, moved up
the filter paper, whereas the inhibitory
principle remained at the point of applica-
tion. A filter paper pile could be used to
purify larger quantities of the inhibitory
material. Cellulose columns were not
satisfactory because both factors ran
through the column without being separated.
Ion exchange has not received enough study
for definite conclusions to be drawn as to
its possibilities as a concentration method.
However, the experiments tried did not
separate the growth and inhibitory factors.

The vitamin $B_{12}$-inhibitory principle was
found to be very stable; it will withstand

freezing and drying and can be kept for weeks in a refrigerator without loss of activity. In dilute solutions of neutral and acid pH it will withstand boiling, but it is readily destroyed by alkali. No change in the absorption spectrum of vitamin $B_{12}$ was observed in the presence of mucosal extracts at pH 7.0. Ventriculin extracts, treated with trypsin, still retained vitamin $B_{12}$-inhibitory activity.

The inhibitory action of Ventriculin extracts was destroyed when they were heated with the basal medium. From the differences observed by heating the inhibitory principle alone and in the basal medium, it appeared that heat was not the destructive agent but that other substances were responsible for the inactivation when the mixture was heated. The constituents of the basal medium were investigated in order to determine the nature of the agents causing destruction of the inhibitory action. Among the substances tested only L-histidine in the presence of iron(II) or manganese(II) caused inactivation of the vitamin $B_{12}$-inhibitor when heated. The

similarity of these structures to benzimidazole and cobalt(II) which form a part of the vitamin $B_{12}$ molecule led to the testing of the latter substances, and they also were found to be effective in destroying the inhibitory activity.

Blood is known to contain small amounts of vitamin $B_{12}$, which are not available to bacteria until the blood is heated or subjected to enzyme action. Blood was fractionated, but this did not aid in locating the vitamin $B_{12}$-binding substance in the experiments performed. Several pure protein fractions from blood were tested for vitamin $B_{12}$-inhibitory activity but were found to be less active than the mucosal extracts. $\beta_1$-metal - combining protein showed a definite inhibition of growth of L. leichmannii. This protein may have caused only an indirect inhibition of growth by removing metal ions from the medium. Acid glycoprotein contained growth factors which were released upon heating. Other blood proteins tested had no significant effect.

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## PROTEOLYTIC ENZYME SYSTEM OF STREPTOCOCCUS LACTIS[1]

### WILHELMUS CARL VAN DER ZANT[2]
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Streptococcus lactis is a common dairy organism and long has been recognized primarily as being saccharolytic. However, various investigations have shown that many strains are capable of causing some protein degradation when grown in milk. It is thought that the enzymes of this organism may contribute to the hydrolysis of protein in cheese and cultured milks. The purpose of this investigation was to study the factors involved in the production of the proteinases of S. lactis and some of the characteristics of this enzyme system in regard to the breakdown of milk proteins.

Proteolysis by three strains of S. lactis grown in skim milk at 32°C. was determined by the increase in acid-soluble nitro-

gen as determined by the Kjeldahl procedure and also by the increase in tyrosine and tryptophan in protein-free filtrates of these cultures. Tyrosine and tryptophan were determined colorimetrically with Folin-Ciocalteau reagent using essentially Hull's method. S. lactis grown in milk caused a rapid increase in both soluble nitrogen and tyrosine and tryptophan during the first 24 hours, followed by a smaller but gradual increase during the rest of the experiment (70 to 90 hours). The increase in acid-soluble nitrogen during the first 12 hours were very slight but definite increases in tyrosine and tryptophan were found within 4 hours. Considerably more soluble nitrogen and tyrosine and tryptophan were found when the pH of the milk was maintained at values ranging from 6.0 to 7.5 than at higher or lower pH levels or in comparable samples without maintained pH. Addition of calcium carbonate to milk cultures of S. lactis permitted greater proteolysis than without calcium carbonate. The lactic acid produced by S. lactis did not cause proteolysis of milk protein. Culture media of various types from which the bacteria had been removed after growth,

1 a. Chairman of Committee, F. E. Nelson, Dept. of Dairy Industry.
   b. Doctoral Thesis No. 1386. Submitted May 17, 1953.
2 a. B.S. Agricultural University, Wageningen, Holland, 1948.
   M.S. Ibid., 1949.
   M.S. Iowa State College, Ames, Iowa 1950.
   b. Graduate Assistant, Agricultural Experiment Station.

iled to show proteolytic activity. In sub-
quent experiments, cell-free extracts
epared by sonic vibration from S. lactis
rown in either milk or broth media were
sted for proteolytic activity on milk,
sein, and lactalbumin as substrates by
etermining colorimetrically with Folin-
iocalteau reagent the amount of tyrosine
nd tryptophan liberated from the substrate
fter incubation with cell-free extract.
roduction of proteinase activity appeared
be partially adaptive, since replacement
f whole protein in the growth medium with
reakdown products of protein decreased
e proteinase activity. Omission of indi-
dual vitamins from vitamin-test casein
edium A affected the organism growth;
mission of nicotinic acid decreased the
roteinase activity more than the growth.
aximum proteinase activity against milk
d casein was found at pH 7.0; optimum
H on lactalbumin was at pH 6.5. α-Casein
as digested somewhat more rapidly than
- and γ-casein. When milk was used as
rowth medium, some indication of a sec-
nd optimum against milk and casein as
ubstrate was found at pH 5.5; this opti-
um, however, was not found when the
ells were grown in vitamin-test casein
edium. Maximum proteinase activity,
ithin the temperature limits studied, was
und at 45°C. Reducing agents activated
e proteinase activity slightly, while me-
llic ions either had no effect or were
lightly inhibitory. The effect of heating
t 50, 55 and 61.7°C. for different lengths
f time was tested at various pH levels of
e cell-free extract. Maximum stability
f the proteinase activity was found at pH
.0. Heating at 61.7°C. for only 2 min-
tes inactivated the preparation. The ex-
ract was inactivated quite rapidly at pH's
.0 and 9.0, even at the lower tempera-
ures. The proteinase activity was quite
table between pH 5.0 and 9.0 during 4
ays of storage at 2°C.; considerable des-
ruction took place at pH's 5.0 and 9.0
hen stored at 32°C.

Cell-free extracts from S. lactis grown
n either milk or broth media were active
gainst seven different peptides; maximum
eptidase activity was found at pH values
anging from 7.0 to 9.0. Hydrolysis of
he peptides was determined by titrating
he liberated carboxyl groups with KOH,

as described by Grassmann and Heyde.
Production of the peptidases active against
glycyl-L-leucine and DL-alanylglycine was
not affected by the absence of whole protein
in the growth medium. Omission of one
vitamin at a time from vitamin-test casein
medium A either had no effect or slightly
decreased the activity of the cell-free ex-
tract against glycyl-L-leucine and DL-ala-
nylglycine; maximum activity against these
two peptides, within the temperature limits
studied, was at 45°C. Cell-free extract
could withstand heating at 61.7°C. (pH 7.0)
for 10 minutes without serious loss of ac-
tivity against glycyl-L-leucine and DL-
alanylglycine; maximum stability was at
pH 7.0. Considerable destruction of acti-
vities against both peptides occurred dur-
ing heating for more than 3 minutes at pH's
5.0 and 9.0. The activities against glycyl-
L-leucine and DL-alanylglycine were quite
stable between pH's 6.0 and 9.0 during 4
days of storage at 2°C. Considerable in-
activation occurred after 4 days at 2°C.
and pH 5.0. Holding at pH 4.0 for 12 hours
destroyed the peptidase activities com-
pletely. Hydrolysis of glycyl-L-leucine
at pH 8.0 was activated by $Mn^{++}$; $Cu^{++}$,
$Zn^{++}$, and $Ni^{++}$ were inhibitory; $Mg^{++}$,
$Co^{++}$ and cysteine had essentially no effect.
In the case of DL-alanylglycine, $Co^{++}$ ac-
tivated the hydrolysis at pH 8.0, $Mg^{++}$ in
0.01 M concentration gave some activation,
$Cu^{++}$, $Zn^{++}$ and $Ni^{++}$ were inhibitory and
$Mn^{++}$ and cysteine were inactive.

Both the proteinase activity and the pep-
tidase activities against glycyl-L-leucine
and DL-alanylglycine were precipitated
from a cell-free extract of S. lactis with
$(NH_4)_2SO_4$ in the range between 40 and 75
per cent saturation and also by absolute
ethanol between 40 and 60 volume per cent
at 7.0. Examination of the protein-free
fraction of milk cultures of S. lactis for
amino acids in the free- and peptide-form
by paper chromatography after incubation
for 24 and 96 hours revealed increases in
the amino acids which already were pre-
sent at 0 hour incubation; some amino acids
not present at 0 hour appeared in the pro-
tein-free filtrate after incubation for 24
and 96 hours. Evidence was presented for
the presence in the protein-free filtrate of
three peptides at 0 hour, five peptides after
24 hours of incubation and six peptides
after 96 hours.

## ELECTRON INJECTION IN BETATRONS AND SYNCHROTRONS[1]

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The purpose of this investigation was to determine theoretically the injection period in a betatron or a betatron-started synchrotron. The elementary consideration of momentum-matching will give the time at which injection should take place. However, it is reasonable to assume that injection can take place over a finite period of time rather than for an infinitesimally short period. It is this interval which is of interest, primarily from the point of view that if the dependence of the interval upon the parameters of injection is known, it may be possible to enlarge the interval with corresponding increases in machine output.

The conditions allowing suitable injection processes have been investigated with the aid of a radial electric potential function. this radial potential is of such a nature that it provides a force on the electron which is exactly equal at all times to the magnetic and inertial forces which are actually present. The shape and position of the assumed potential function can then be investigated for varying parameters of injection in order to determine what ranges will give injection.

Two general cases have been considered. The first is that of constant voltage or constant momentum injection, the problem being to determine the time interval over which the mono-energetic electrons can be accepted by the magnetic field. In terms of the assumed potential, this becomes a determination of the period during which suitable potential functions exist. The following equation results from this analysis.

$$\Delta t = \frac{P_1^2 r_i(r)}{K_1 e^2 r_i \left[ A'_\theta (r_i) \right]^2} \tag{1}$$

where

$\Delta t$ is the period of acceptance,

$P_i$ is the momentum of injection,

$K_1$ is the time slope of the magnetic field in the region of injection,

e is the electronic charge,

$r_i$ is the radius of injection,

$A_\theta(r_i)$ is an increasing function of the radius of injection, the form of the function being

$f_1(r)$ dependent upon the field shape and is a function of the field shape.

For a given machine Eq. (1) states that the acceptance period is directly proportional to the momentum of injection, is inversely proportional to the slope of the magnetic field and will decrease with an increase in the radius of injection.

The second case that has been considered is that where the injection momentum is being changed during the acceptance period. A momentum function composed of a linear rise and a linear drop has been used as an approximation to the injection pulse. For injection in the region of the linearly rising momentum.

$$\Delta t = \frac{\gamma \Delta P_\theta''}{K_1 r_i \left[ \alpha / K_1 - e A'_\theta (r_i) \right]^2} \tag{2}$$

and for a linearly decreasing momentum,

$$\Delta t = \frac{P \Delta \rho''_\theta}{k_1 r_i \left[ \alpha / K_1 + e A'_\theta (r_i) \right]^2} \tag{3}$$

In Eqs. (2) and (3) $\alpha$ is the time slope of the momentum function while $\gamma$ and $\hat{\rho}$ are intercepts. The term $\Delta \rho''_\theta$ is again a function of the radial field configuration and is a constant for a given machine.

Possibilities for a form of momentum matching and large acceptance times are shown by the negative sign in the denominator of Eq. (2).

An attempt was also made to determine the duration and location of the acceptance periods in the Iowa State College synchrotron by the use of a pulse perturbation technique. The only place an acceptance time could be definitely located was at the peak of the injection pulse. For normal operating conditions the acceptance time was measured as 1.4-1.5 microseconds.

1 a. Chairman of Committee, George R. Town, Dept. of Electrical Engineering.
  b. Doctoral Thesis No. 1408. Submitted June 3, 1953.
2 a. B.S. Iowa State College, Ames, Iowa, 1943.
     M.S. Ibid., 1948.
  b. Assistant Professor, Dept. of Electrical Engineering.
     Associate Engineer, Institute of Atomic Research.

## AGRICULTURE AND FEDERAL ANTITRUST ACTIVITY:
## AN ECONOMIC HISTORY AND ANALYSIS[1]

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The main objective of this study was to determine the relationships between agriculture and federal antitrust activity. Historical analysis of events from 1850 to the present was employed.

The years 1850-1890 were ones of great change in the American economy, with a transformed agriculture finding itself in a new industrial age. As prices of agricultural products fell after the Civil War, the farmer accused those having dealings with agriculture of using their monopoly positions to his disadvantage. Farmers' groups sprang up to meet the "menace of monopoly". These organizations established associations to attack "monopolies" through the device of cooperative purchasing, marketing and manufacturing and also took important antimonopoly action on the political front.

"Granger" legislation was passed in the states, and federal regulation of the railroads was established by the Interstate Commerce Act of 1887. After 1876, margins of victory in national elections were very narrow. The fact that many farmers supported reformist third parties caused the major parties, especially the Republican party, to sponsor measures calculated to regain the vote of the Western Farmer.

In order to placate the Western wing of their party, the Republicans put the Sherman Antitrust Act of 1890 on the statute books. This piece of legislation, along with others, passed with similar intent the same year, failed to achieve its purpose, with the Republicans being defeated in the elections of 1890 and 1892.

Early administration of the antitrust legislation was ineffective, even halfhearted, and afforded little relief to agriculture. From 1890-1896, the agrarian revolt reached its peak, with the People's party giving political expression to the antimonopoly sentiments of the farmer.

With the defeat of the Populists in the election of 1896, returning prosperity and some apparently favorable court decisions under the Sherman Act, agricultural pressure for antitrust legislation declined. Af-

ter federal courts in 1908 and 1910 held that farmers and their organizations came under the antitrust laws, there was agitation for exemption of agricultural producers. A wave of combination swept over the nation at the turn of the century, and there was a general increase in antitrust sentiment for new regulatory legislation. The movements resulted in some exemption for agriculture from the antitrust laws and the Clayton and Federal Trade Commission Acts of 1914.

The new legislation was not satisfactory to agriculture--although use was made of the F.T.C.--and the twenties saw a new approach taken to solving the problem of "monopoly". The Capper - Volstead Act gave the first effective exemption to agricultural organizations from the antitrust laws. "Trusts" were dealt with directly through the passage of the Packers and Stockyards Act and the Grain Futures Act.

The antimonopoly legislation of the twenties was not achieved as the result of Republican fears of a farmer-supported third party, but rather through the operations of a bipartisan "farm bloc". An attempt by Senator Robert LaFollette to establish a successful antimonopoly third party with agrarian support was short-lived and was not as effective as the farm bloc in influencing federal and antitrust activity.

After 1925, and especially during the early thirties, there grew among agricultural groups the realization that antimonopoly legislation would not serve to restore the relative position of agriculture. The Agricultural Adjustment Act of 1933 permitted, in its section concerning marketing agreements, greater latitude to cooperative associations in combining with processors and handlers than the Capper-Volstead Act provided. There also was agricultural support for the relaxation of the antitrust laws under the National Industrial Recovery Act, although some agrarian Senators objected vigorously.

When the depression did not come to a speedy end, and expecially after the recession of 1937-1938, there was increased agrarian sentiment for a revival of the antitrust laws. New legislation was introduced by agrarians in Congress, Senators from farm states were placed on the Temporary National Economic Committee and general farm organizations urged the passage of new legislation and the vigorous

prosecution of existing antitrust laws.

The increased federal antitrust activity
was brought to a halt by the entrance of the
United States into the war and what results
there were gave small comfort to agricul-
ture. The war brought prosperity to the
farmer and there were notable shifts in the
views of some of the major general farm
organizations. With cooperative associa-
tions secure in their exemption from pro-
secution, and with a prosperity-born con-
servatism, there was a tendency to take
a more tolerant view of industrial combi-

nation and to express more concern over
"labor monopoly" and "government mono-
poly".

Among major general farm organiza-
tions, only the Farmers' Union, a direct
descendent of Populism, is still concerned
with industrial monopoly. With the change
in attitudes of the larger farm organiza-
tions, and with the disappearance from the
Senate of agrarian antimonopolists, there
is little immediate prospect of agricul-
ture's being in the forefront of any new
drive against industrial monopoly.

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## THE EMBRYOLOGY OF THERMOBIA DOMESTICA PACKARD[1]

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Cleavage in Thermobia domestica is
superficial, the centrally located zygotic
nucleus dividing repeatedly to give rise to
daughter nuclei which migrate to the peri-
pheral region of the egg. By 18-19 hours,,
these nuclei together with their cytoplasm,
have formed a thin epithelium surrounding
the yolk. The cells in this primary epithe-
lium soon become more numerous at the
posterior end of the egg, and by 25 hours
a small germ disc may be seen at this end.
Within a short time this disc elongates to
form a germ band. The remainder of the
primary epithelium becomes the serosa.

Beginning at about 40 hours, cells from
the germ band begin to migrate inward to-
ward the yolk. They form a deeply stain-
ing layer, the cells of which are flattened
in a direction vertical to the cells of the
germ band. The formation of this layer
follows no regular pattern. Instead, cells
migrate inward, apparently at random,
from any part of the germ band. The outer,
original germ band is ectoderm, while the
newly formed inner layer is mesoderm.

As the germ band develops, it sinks into
the yolk only very slightly. As it sinks in-
ward, its edges give rise to a thin mem-
brane connecting the edges of the germ
band and the serosa. This new membrane
is the amnion. The amnion never closes,
so that the embryo is never completely
covered by this membrane.

At 44-45 hours a slight invagination may
be seen near the posterior end of the germ
band. This is the beginning of a deep ab-
dominal loop, which remains until eclosion.
It is the point at which the embryo will be
doubled back on itself when the embryo be-
comes longer than the egg. A little later
the stomodeal and proctodeal invaginations
become evident.

By the forty-sixth hour the head becomes
distinguishable from the rest of the body
by a transverse groove, and by 48-49 hours
the mandibular, maxillary, and labial seg-
ments may be distinguished. The appear-
ance of these segments is followed shortly
by the appearance of the thoracic and ab-
dominal segments. A pair of small evagi-
nations, the appendage primordia, may be
distinguished on each segment soon after
the segment becomes apparent. The ap-
pendage primordia of the abdominal seg-
ments disappear within a short time, ex-
cept for the pleuropodia on the first seg-
ment, which persist until just after blasto-
kinesis. Coelomic sacs develop in each
segment. Six segments appear in the head,
three in the thorax, and eleven in the ab-
domen. Four pairs of coelomic sacs de-
velop in the head, three in the thorax, and
ten in the abdomen.

During the fourth day the serosa con-
tracts at the anterior end of the egg, the
cells at that point sinking into the yolk and
disintegrating to form a secondary dorsal
organ. As the serosa contracts, it pulls
the amnion toward the anterior end of the
egg. This membrane in turn pulls the em-
bryo, head first, around to the ventral side
of the egg. At no time during this process
of blastokinesis does the embryo lose con-
tact with the periphery of the egg.

1  a.  Chairman of Committee, Howard L.
        Hamilton, Dept. of Zoology and
        Entomology.
    b.  Doctoral Thesis No. 1393.  Submitted
        May 28, 1953.
2  a.  B.S. Iowa State College, Ames, Iowa
        1944.
    M.A. University of Kansas, Lawrence,
        Kansas, 1948.

As the embryo grows laterally upwards around the yolk, the cardioblasts appear at the junction of the splanchnic and somatic mesoderm. When the two sides meet, the cardioblasts form the tubular heart. Spiracular invaginations form on the sixth day. A total of ten pairs develops, one pair on each of the first two thoracic segments, and one pair on each of the first eight abdominal segments. These ectodermal invaginations extend only a short distance into the body before they become indistinguishable from the mesoderm. As with the reproductive system, the tracheal system undergoes most of its growth after eclosion.

Germ cells were not seen in early stages of Thermobia. No oosome develops. The germ cells in the embryo are distinguishable later principally by their position ventromedial to the coelomic sacs. Reproductive organs are not apparent in the embryo. The fore-gut and hind-gut develop from ectodermal invaginations near the anterior and posterior ends of the body. They are very clearly ectodermal, as are the four Malphigian tubes which begin as evaginations from the hind-gut near its junction with the mid-gut.

The mid-gut epithelium develops later than the rest of the alimentary canal. At the time of hatching it is not complete. The cells present in this epithelium at eclosion arise from two sources: (1) proliferations from the ectoderm of proctodeum and stomodeum, and (2) cells migrating peripherally from the yolk. More of the cells have their origin from the latter source.

The nervous system develops in a manner common to most insects. Neuroblasts at each side of a neural groove give rise to ganglionic cells. Seventeen pairs of ganglia, exclusive of the brain, develop in Thermobia. One pair develops in each of the three gnathal segments, one pair in each of the three thoracic segments, and one pair in each of the eleven abdominal segments. Later the ganglia of abdominal segments nine, ten, and eleven fuse with the ganglia of abdominal segment eight.

The brain arises in a manner similar to that of the ventral ganglionic chain. The optic lobes, however, do not form from neuroblasts, but instead by delamination from the ectoderm of the eye region. Later, the eye plate forms in the ectoderm in the same region as that which gave rise to the optic lobes.

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## COMPARISON OF COSTS OF SERVICE AND SELF-SERVICE METHODS OF SELLING MEAT IN RETAIL FOOD STORES[1]

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Department of Economics and Sociology

The question of the difference in cost between service and self-service methods of selling meat in retail food stores has been of interest to the retail food industry for a number of years. The major purpose of this study was to compare the costs of selling meat self-service with the service methods in various sizes of stores. A second major purpose was to determine how the cost varied as the size of the store increased.

Data for the study were collected in forty-nine meat departments in various size retail food stores. Twenty-six of these were

service and twenty-three were self-service. A stratified random sample was used for service stores. This procedure was not strictly adhered to for self-service stores because of insufficient numbers over a desired volume range. The basis for stratification was dollar volume of meat department sales. The meat departments varied in size from $500 to $11,000 sales per week. Dollar volume of sales was used as a measure of size. Four cost factors were studied; these were labor, paper supplies, square feet of floor space and equipment investment. Generally, physical data were collected and converted to costs in dollar terms. It is believed these costs make up from 80 to 85 per cent of the cost of selling meat in retail food stores. It is also believed that the remaining costs, shared with the stores' other operations, would not alter the results. Comparisons between service and self-service methods were made in terms of both physical factors and dollar costs.

Regressions of labor cost, floor space, equipment investment, paper supplies and a combination of these, in terms of combined cost, on meat department sales volume were computed for both service and self-service methods of selling meat. The significance of differences between the coefficients of regression for each method and between selected regression values was tested by means of students' "t" at the one and five per cent levels of probability.

The results of the study may be summarized as follows:

1. Physical hours of labor averaged lower under self-service than service methods from $/500 to about $/2000 sales per week. From $/2000 to $/7000 sales per week, self-service required more physical hours of labor.

2. When the physical hours of labor were converted to dollar costs, taking account of differences in job classifications and thus wage scales, the self-service method cost less throughout the range in size from $500 to $7000 sales per week.

3. Investment in equipment averaged from $400 higher in self-service meat departments at $500 sales per week to $3000 higher than service markets at $7000 sales per week.

4. There was no difference between the two methods in the average amount of floor space used by the meat department. Thus there would be no difference in the rental charge between the two methods of selling meat.

5. Cost of paper supplies averaged about 1.6 per cent of sales in self-service markets and about 1.2 per cent of sales in service markets.

6. When the dollar costs of labor, equipment, floor space (rent) and paper supplies were combined into one cost, no significant difference in cost could be observed between service and self-service methods of selling meat. The differences in the individual costs, noted above, apparently cancel when these costs are combined. Thus, at any given volume of sales (in the range $500 to $7000 per week) the average costs under service and self-service operation are apparently not sufficiently different to be considered of practical importance.

7. The average cost curves under both methods of selling show that the cost of retailing meat decreases considerably as the size (volume of sales) of the market increases. The cost decreases most as markets increase in size from $500 to about $3000 sales per week.

Several interesting conclusions may be drawn from the above results and from the general aspects of the study. They are briefly stated below:

1. Most stores that have converted to self-service have experienced an increase in sales volume. Thus, upon conversion, such stores would move along the average cost curve toward the right, and cost per pound would fall as sales increase.

2. Both service and self-service markets, at any given volume, can decrease their costs if they increase their volume. If the market is in a volume range less than $3000 sales per week, the decline in costs as sales volume increases is much greater than at sales volumes above $3000 sales per week.

3. Self-service meats will likely encourage the trend toward larger type food stores. The trend in new construction is toward larger stores and a change from service to self-service generally involves modernization and new construction.

4. Self-service methods may eventually lead to centralized pre-packaging. This might likely be done by firms set up for this function, by the packers, or by chains for their own stores. A number of instances of success in this field can be cited already and research is continuing. However, technological problems will likely delay this development for quite a few years.

5. Self-service has been an excellent solution to the "rush hour" problem. Consumer acceptance is no longer considered a major problem. Self-service meats ease the problem of skilled labor, increase the percentage that meat sales are of the total sales, promote rapid turnover thus decreasing inventory and are "in tune" with modern merchandising. It is most likely that self-service methods will in a few years account for the greatest proportion of meat sales.

6. Self-service methods have generally helped to move the economy cuts, often at higher prices. This is most likely a reflection of "real" consumers' preference which has not been given the opportunity to show up in service markets. Part of this study may also be due to impulse buying.

7. There is some reason to believe that self-service methods may be affecting the demand for meat, presumably increasing it. The determination of a change in demand is a complicated problem, however. The answer to the problem of a real change in demand will probably be delayed for a while until a sufficient number of self-service markets have been in operation for some time so that quantitative data can be made available for research purposes.

## ACTION PATTERNS OF STARCH ENZYMES[1]

GENE MURIEL WILD[2]
Department of Chemistry

The actions of several enzymes on starch and starch degradation products were investigated by paper chromatographic studies. These enzymes included the phosphorylase of potatoes, of broad beans and of several other plants, salivary amylase, beta amylase of sweet potatoes and of soybeans, Q-enzyme from broad beans and from potato and R-enzyme from broad beans.

The limit dextrins from waxy maize starch were prepared with sweet potato beta amylase, potato phosphorylase and salivary amylase. Glycogen beta amylase limit dextrin was prepared with soybean beta amylase. The above limit dextrins are high molecular weight products, except for the salivary amylase limit dextrins.

The action of saliva proceeds in several phases. An initial rapid breakdown of amylopectin to maltose ($G_2$), amylotriose ($G_3$), and amylotetraose ($G_4$), and dextrins containing one to several branches per molecule is followed by a slower hydrolysis of $G_4$ to $G_2$. At a still slower rate, $G_3$ is hydrolyzed to $G_2$ and glucose and a series of four relatively stable branched dextrins ranging from 4 to 7 glucose units are formed. A second series ranging from 8 to about 13 glucose units contained two branches per molecule. Other higher compounds were formed. At an extremely slow rate, saliva caused the hydrolysis of maltose to glucose, with an accompanying weak transglycosidase activity. This was shown by the detection of small amounts of branched trisaccharide ($B_3$) and $G_3$ in the maltose digests. The action of a soybean beta amylase preparation on maltose and on $G_3$ was shown to be very similar to that of saliva.

R-enzyme was definitely demonstrated to hydrolyze alpha-1,6 linkages by its conversion of isomaltose to glucose and of panose (isomaltosyl glucose) to glucose and maltose. The action of R-enzyme was tried on the above limit dextrins.

From the products obtained, it was concluded that the branches in phosphorylase limit dextrins were 3 and 4 glucose units long; the branches in the beta amylase limit dextrins were 2 and 3 glucose units long with some branches of 1 glucose unit. With extended beta amylase action, the 3 glucose unit branches are no doubt shortened by one maltose unit by beta amylase. Light acid hydrolysis studies gave similar results.

The branched limit dextrins from salivary amylase action on waxy maize starch were separated and isolated by paper chromatography. The action of R-enzyme was investigated on each. R-enzyme had only a slow action on the branched tetrasaccharide ($B_4$) with the production of a small amount of glucose. About 50 per cent of the $B_5$ fraction was readily hydrolyzed to $G_2$ and $G_3$. Approximately 75 per cent of the $B_6$ component was hydrolyzed to $G_2$ and $G_4$. Substantially all of the $B_7$ was hydrolyzed to $G_3$ and $G_4$. The results from acid hydrolysis studies of $B_4$ and $B_7$ and of their aldonic acids indicated that the $B_4$ structure was either O-Q-O- or Q-O-O-, and that $B_7$
      $\overset{O}{\phantom{.}}$    $\overset{O}{\phantom{.}}$

was either O-O-Q-O- or    O-Q-O-O-;
      O-O-Q              O-O-Q
(...O-O... indicates a maltose linkage;
Q... indicates an isomaltose linkage).
...Q

Potato phosphorylase was used as a detecting reagent on the paper chromatograms. A chromatogram sprayed with a solution containing phosphorylase and glucose-1-phosphate and incubated in a moist chamber gave areas, after spraying with iodine, where starch synthesis was primed by certain sugars. Amylotriose was a weak primer; amylotetraose and higher linear sugars were very good primers. This reagent was much more sensitive in detecting priming sugars than the alkaline copper-phosphomolybdic acid sprays used for reducing sugars. The impure phosphorylases of broad beans, peas, jack beans, and lima beans had like priming needs which differed from those of potato and corn. Sugars containing one less glucose unit were effective as primers with these phosphorylases. Maltose was a weak primer for these phosphorylases.

Q-enzyme was shown to act on substrates of low molecular weight includ-

ing maltose, $G_3$, $G_4$, $G_7$, isomaltose, panose and sucrose. From the results of experiments on these sugars it was concluded that Q-enzyme exhibited reversible transglucosidase action on 1, 4 bonds

and on 1, 6 bonds in addition to its transfer of 1, 4 and 1, 4 bonds. Q-enzyme catalyzed the transfer of the glucose unit of sucrose to form 1, 4 and 1, 6 bonds.

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# EFFECT OF MILK PRODUCTS RECONSTITUTED WITH DIFFERENT FATS ON GROWTH AND BLOOD CONSTITUENTS OF DAIRY CALVES[1]

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Department of Animal Husbandry

This study (divided into four experiments) was designed to study the effects of restricted milk diets containing various types and amounts of fat and other constituents upon certain physiological responses of the dairy calf. The criteria were body weights; incidence of diarrhea; vitamin A, carotenoids, fat, calcium, and inorganic phosphate levels of blood plasma; hemoglobin and reducing sugar levels of blood; vitamin A storage; and apparent digestibility of fat.

In experiment I, thirty-five calves were randomized into 8 groups and fed reconstituted milks at the rate of 10 pounds per 100 pounds of body weight daily. Supplemental vitamin A was administered in capsules. Rations with 84 per cent water contained the following solids, respectively; (a) 16 per cent non-fat dry milk solids, (b) 11 per cent non-fat dry milk solids and 5 per cent dried whey product, (c) 9 per cent non-fat dry milk solids and 7 per cent dried whey product, (d) 8 per cent non-fat dry milk solids and 8 per cent dried whey product, (e) 10 per cent non-fat dry milk solids and 6 per cent hydrogenated soybean oil, (f) 5 per cent non-fat dry milk solids, 5 per cent dried whey product, and 6 per cent hydrogenated soybean oil. Rations containing 87 per cent water varied as follows: (a) 13 per cent non-fat dry milk solids, (b) 8 per cent non-fat dry milk solids, 5 per cent dried whey product.

Scouring was less frequent on rations containing fat than on milks of approxi-

mately equal caloric value composed only of reconstituted milk solids - not - fat. Moreover, it was observed that inclusion of dried whey product resulted in more scouring both in low-fat groups and in groups fed hydrogenated soybean oil. It was further observed that approximately 1.6 pounds of milk solids-not-fat per 100 pounds of body weight daily were required in low-fat diets for support of satisfactory growth. When lesser amounts of milk solids-not-fat were fed, growth was markedly sub-normal, These data served as guides in formulating rations for further study.

In experiment II, milks containing 87 per cent water included the following solids, respectively: (a) 10 per cent non-fat dry milk solids and 3 per cent hydrogenated soybean oil, (b) 5 per cent non-fat dry milk solids, 5 per cent dried whey product and 3 per cent hydrogenated soybean oil, (c) 10 per cent non-fat dried milk solids and 3 per cent butter oil, (d) 5 per cent non-fat dry milk solids, 5 per cent dried whey product, and 3 per cent butter oil. Rations containing 82 per cent water included, respectively: (a) 18 per cent non-fat dry milk solids, (b) 13 per cent non-fat dry milk solids and 5 per cent dried whey product. Whole milk (3 per cent fat) was fed to animals in a control group. All milks other than whole milk were homogenized. Feeding rate was 10 pounds of milk and 12,000 International Units vitamin A per 100 pounds body weight daily. Seven calves were allotted at 4 days of age to each ration and the experiment continued to sixty days of age.

Plasma vitamin A levels were similar and initially averaged 16.5 micrograms per cent for whole milk and butter oil groups. The final mean for all calves fed milk fat was 15.2 micrograms per cent. Average values for low-fat and hydrogenated soybean oil groups decreased from 18.4 to 10.8 micrograms per cent during the same period. Blood plasma carotenoid data were similar for calves

in the whole milk and the butter oil groups. The initial mean value for calves fed milk fat was 21.6 and the terminal level was 13.6 micrograms per cent. For calves in the other groups (low-fat and hydrogenated soybean oil) the mean initial carotenoid value was 20.4 and the final level was 1.3 micrograms per cent. These differences were due at least in part to differences in the amounts of vitamin A and carotenoids ingested.

Mean plasma fat concentrations were highest for calves in the whole milk group, initially averaging 127 and increasing to 165 mg. per cent when calves were 60 days of age. Butter oil groups were next highest, initially averaging 120 and decreasing to 152 mg. per cent. Hydrogenated soybean oil groups had an initial average of 118 and a final mean of 88 mg. per cent. Values for low-fat groups decreased from an initial mean of 25 to a final average of 30 mg. per cent. There were no apparent adverse physiological effects resulting from low blood plasma fat levels.

Since there were no apparent differences among the various dietary groups in the other blood constituents investigated, the group mean values were combined to es-

tablish average trends for calves in the restricted dietary regimes employed in this study. The mean values at 4 and at 60 days, respectively, were reducing sugar, 86 and 64 mg. per 100 ml. blood; hemoglobin, 12.2 and 10.2 grams per 100 ml. blood; calcium, 12.0 and 10.1 mg. per 100 ml. blood plasma; and inorganic phosphate, 6.7 and 5.9 mg. per 100 ml. blood plasma.

One or more calves from each of the various dietary regimes in experiment II were depleted of vitamin A reserves to measure vitamin A storage (experiment III). Calves removed from whole milk were not depleted in eight weeks. Animals from the butter oil groups reached depletion in a minimum of six to eight weeks. Hydrogenated soybean oil and low-fat groups were depleted in one to four, and three to six weeks, respectively.

Limited digestion balance trials (4-day preliminary periods and twenty-four hour collection periods) were used to investigate the digestibility of hydrogenated soybean oil. Results indicated that the apparent digestibility of this oil is approximately 92 per cent which is similar to that of butter fat.

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# GENETIC COVARIATION OF EGG PRODUCTION AND OTHER ECONOMIC TRAITS IN POULTRY[1]

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The primary purpose of this investigation was to estimate heritabilities and genetic correlations involving certain performance traits in chickens.

Data from nine breeds, which included 8 distinct lines of breeding, were studied. These data involved 1960 pullets from 609 dams and 159 sires and covered a five-year period. Traits studied were egg weight, egg production rate for three periods, and body weight at eight weeks, at housing, and in March. Housing weights were corrected to a constant age.

- a. Chairman of Committee, A.W. Nordskog, Dept. of Poultry Husbandry, and John W. Gowen, Dept. of Genetics.
- b. Doctoral Thesis No. 1412. Submitted June 5, 1953.
- a. B.S.A. University of Arkansas, Fayetteville, Ark., 1949. M.S. Iowa State College, Ames, Iowa, 1951.
- b. Graduate Assistant, Agricultural Experiment Station.

Preliminary analyses indicated that date of hatch had little influence on the traits studied. Interactions of lines with hatches were found to be negligible.

Genetic analyses were based on intraline and year variances and covariances. Heritabilities and genetic correlations were calculated from regressions of daughter on dam.

Estimates of heritability, adjusted for an average inbreeding of 19 per cent, were as follows: egg weight, 0.52; production rate (December 1 to March 1), 0.11; production rate (March 2 to May 31), 0.0; production rate (first egg to May 31), 0.0; body weight at eight weeks, 0.39; housing weight, 0.18; March body weight, 0.52. These estimates are biased to the extent that epistasis is important.

Negative genetic correlations of -0.43 between winter rate and egg weight and -0.31 between winter rate and March body weight were found. Even though these cor-

relations are subject to large sampling errors, they indicate that selection for increased winter rate will be accompanied by a decrease in both egg size and March body weight. These antagonistic genetic relationships, together with the low heritability found for egg production, may be responsible for the slow progress in breeding for egg production in recent years.

Estimates of genetic correlation among the body weights were all positive and high. In addition, the genetic correlation between egg weight and March body weight was

0.30. Hence, selection for March body weight would appear to improve body weight at other ages as well as egg weight but would decrease winter rate.

Presence of negative genetic correlations between desirable traits, such as those found in this study, limits the genetic progress possible by selection. Selection based on production rate alone would soon need to be interrupted to give attention to the decrease in egg weight and March body weight which would result.

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# INTERACTION BETWEEN PROTEINS AND SURFACE ACTIVE IONS[1]

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Department of Chemistry

In recent years numerous investigations have been published on the protein-ion interaction. Of particular interest are the surface active ions which exhibit markedly strong affinity for proteins as compared with other organic ions and thus produce many diverse effects on proteins and biological systems. This field of interest is, however, not yet fully exploited and, consequently, controversy with regard to the nature of binding between proteins and surface active ions still exists. Therefore, in this thesis it was attempted to further investigate such binding affinity, to clarify at least part of the foregoing controversy, and to correlate the protein-ion interaction with the structural changes of the protein.

## I. Competitive Interaction between Proteins and Surface Active Anions.

Three proteins, ovalbumin, bovine albumin and zein, and a surface active anion, sodium dodecylbenzenesulfonate (SDBS), were studied electrophoretically. Stable complexes of albumin-SDBS were prepared by two methods: (1) prolonged dialysis of mixtures of protein and excess SDBS against distilled water, or (2) acid precipitation of albumin-SDBS complexes, followed by redispersion in alkaline solution. Zein-SDBS complex was prepared

by extracting the protein in excess with SDBS colution.

Definite interaction between Zein-SDBS and ovalbumin was observed with the appearance of an ovalbumin-SDBS component at the expense of the native ovalbumin. No displacement reaction occurred with mixtures of Zein-SDBS and bovine albumin. Likewise, ovalbumin removed the bound anion from bovine albumin-SDBS complex, but no interaction was detected for mixtures of ovalbumin-SDBS and bovine albumin. It was postulated that competitive interaction is closely related to the different binding affinities of the proteins for the anions.

## II. Interaction between Proteins and Surface Active Cations.

Electrophoretic analyses of mixtures of albumins and zephiran, a surface active cation, revealed strikingly different behavior between the two proteins studied. In the case of ovalbumin an "all-or-none" reaction took place, whereas for bovine albumin the cation was only loosely adsorbed.

Preparation of protein-zephiran complexes failed. Mixtures of ovalbumin and zephiran yielded gels on prolonged dialysis, mixtures of bovine albumin and zephiran yielded regenerated protein. This again indicated the difference in binding affinity between the proteins and close relation between interaction and denaturation.

I. Quantitative Study of Interaction
between Protein and Surface Active
Anion.

The combination of bovine albumin and
ovalbumin with SDBS was studied by a
combination of equilibrium-dialysis and
electrophoresis. SDBS could be deter-
mined in the dialyzates by ultraviolet ab-
sorption ($\lambda$ max. = 223 m$\mu$) at concentra-
tions as low as $10^{-5}$M. The binding curve
covered a wide range of SDBS concentra-
tion, the protein concentration being kept
constant. Electrophoretic analyses re-
vealed three regions in the binding curve
of bovine albumin. In the first stage
(region A) interaction was statistical with
a limit of about ten ions per molecule. In
the second stage (region B) the reaction
was "all-or-none", giving rise to a com-
plex containing about fifty ions, which
corresponded to about one-half of the basic
groups of the protein. In the third stage
(region C) statistical combination again
occurred, no upper limit being attained
even in saturated SDBS solution under the
conditions employed (in phosphate-NaCl
buffer of pH = 7.6 and ionic strength = 0.20,
at 1-3 °C.).

A kinetic study at constant SDBS activity
indicated that the reaction in region B was
of the first order with respect to the pro-
tein. Complete reversal of the second and
third stages was not achieved, indicating
the strong binding affinity between the
protein and surface active anion. The
binding curve was also concentration-
dependent to some extent. Quantitative
studies were somewhat complicated by the
inhomogeneity of the surface active com-
pounds employed.

Similar experiments were conducted for
the binding of SDBS of ovalbumin. The
first statistical stage was found to be ab-
sent, whereas the second "all-or-none"
stage appeared with binding of about forty
ions per molecule of the protein, which
was equivalent to one ion per basic group
of the protein.

A hypothesis was suggested for the bind-
ing process. The first stage was postu-
lated as a fast reversible reaction, involv-
ing no structural change of the protein.
Probably only virtual equilibrium was at-
tained in region B, due to the irreversible
and the slow characteristics of the "all-
or-none" step. This step was presumed
to involve denaturation of the protein. In
region C the protein molecule was further
disrupted by the penetration of surface
active ions in a statistical manner. Con-
troversy on the binding process as raised
in the literature was thus at least partly
clarified. The absence of the initial re-
gion A in the case of ovalbumin suggested
that this protein was more labile than bo-
vine albumin and was denatured by the
first ions bound. This was in good agree-
ment with the conclusion obtained in Parts
I and II.

IV. Some Flow Birefringence Studies
of Protein-Surface Active Anion
Complexes.

Denaturation of protein-SDBS complexes
was briefly investigated with flow bire-
fringence measurements. Both ovalbumin-
SDBS and bovine albumin-SDBS complexes
(prepared by acid precipitation method)
exhibited strong anisotropy of flow, indi-
cating the unfolding of the protein mole-
cule. The interpretation of the results,
however, was complicated by the state of
aggregation. Future methods of approach
were outlined. It was pointed out that
correlation of protein denaturation with
the nature of binding would offer one of the
most promising sources of information on
protein structure.

## TOXICITY AND TRANSLOCATION OF HERBICIDES[1]

DALE W. YOUNG[2]

Department of Botany and Plant Pathology

The effectiveness of a herbicidal mixture depends upon its acute or chronic toxicity, combined with the ability of the plant to translocate a lethal amount into the roots and growing regions. Some herbicides exhibit maximum acute toxicity, destroy foliage on contact, and may be described as chemical mowers. Contact herbicides are effective on annuals but have limited value on perennial plants.

Herbicides exhibiting chronic toxicity may be divided into those that are absorbed by the roots and translocated to the above ground tissues, and those absorbed by leaves and translocated to the below ground tissues. In general, translocated herbicides exhibit low initial toxicity. Injury to the plant is cumulative and chronic toxicity may be manifest first in the meristematic regions, then throughout the plant.

The purpose of this study was to measure the relative toxicity of various herbicides, with special emphasis on synergistic effects of herbicidal combinations, and to determine the factors affecting translocations of herbicides.

### Toxicity

Toxicity was studied by treating vegetation on field and ballast areas with various chemicals and combinations of chemicals at all seasons of the year, at varying rates and concentrations per acre.

Forty pounds of TCA sodium salt and 80 pounds of sodium chlorate per acre have given generally good control of quack grass, smooth brome grass and miscellaneous weeds. This mixture is definitely synergistic, and results with it have been as good as with 400 pounds of sodium chlorate used alone and better than 100 pounds of TCA alone. TCA-chlorate was the least expensive of the treatments and was not significantly poorer than the best.

CMU was tested extensively. Rates of 20 pounds per acre have given excellent control of quack grass and smooth brome grass. Ten pounds of CMU in combination

with 80 pounds of sodium chlorate per acre has given as effective control as 20 pounds of CMU used alone on most plants in Iowa. The addition of two pounds per acre of 2, 4-D, DNC or 10 gallons of oil to a CMU spray has not increased the toxicity.

Early applications of herbicides, just as the perennial grasses appear in the spring, have given better results than late spring, and mid-summer or later applications may give poor control. The CMU-chlorate spray applied in April or May held the areas free from weeds during the season, but allowed reinfestation with annual weeds the next year. TCA-chlorate sprays were nearly as effective on perennial plants, but reinfestation with annuals was more rapid. At present, follow-up treatments with toxic oils could be used at a total cost below that of CMU-chlorate.

Oil with an aromatic content above 50 per cent and a boiling range between 500 and 700°F. may be an effective contact herbicide. At least two sprays of the high aromatic, high cycle oils at rates of 60 gallons per acre were necessary. The oils can be applied for approximately the same price as burning, with the advantage of no fire damage and some preservative value for ties and rails. The special value of oils probably lies in re-treatments after perennials have been removed by other chemicals.

### Translocation

Translocation studies were conducted in field areas with mesquite, using the shield method, and in the greenhouse with soybeans, using a leaf immersion technique. Results are reported as the amount of branch kill or inhibition of the trifoliate leaves. 2,4,5-T and 2,4-D esters or amines with wetting agents were translocated equally well in mesquite, while in soybeans high concentrations of some esters were not translocated as readily as amines. Oil emulsions of 2, 4-D salts were more effective than aqueous solutions. The action of the oil is not known. It has been thought to facilitate penetration, possibly by keeping the herbicide in moist contact with the plant tissue longer than water solutions. These experiments have shown that it is the emulsifying or wetting agent that increases the effectiveness of the herbicides, and the oil is of limited value.

Translocation was slowed or stopped

en plants were held at low temperatures,
t resumed when the plants were returned
normal temperatures. Temperatures
80°F. favored translocations in mes-
ite. Translocation was also greatest in
esquite in late spring. Leaves, flowers
d early new growth appear at the expense
the stored food, and food reserves are
t replenished until after the full canopy
leaves is established. Translocation
is greatest when the root reserves were
ing replenished. In soybeans, a carbo-
drate supply was necessary for trans-
cation of herbicides. Whether the carbo-
drate activated the transporting mecha-
sm or whether the 2,4-D moved with the
rbohydrate was not determined.

Translocation of herbicides was not sig-
ficantly reduced when plants were under
stress for moisture. However, when plants
were under stress for moisture, growth
was reduced, differentiation accelerated
and absorption of chemicals was slower.
In mesquite there was no correlation be-
tween accumulated rainfall before treat-
ment and translocation of herbicides.

Toxic materials combined with 2,4-D
reduced translocation by injuring the trans-
located tissues. In soybeans, 0.5 per cent
toxic wetting agent prevented translocation
of 2,4-D at concentrations above 500 ppm.,
while, with a similar concentration of non-
toxic wetting agent, translocation of 2,4-D
increased with the concentration up to
10,000 ppm. A toxic wetting agent, how-
ever, permitted translocation of lower
concentrations of 2,4-D than a nontoxic
wetting agent.

## MASTERS' THESES

### Accepted July 1, 1952 - June 30, 1953*

### SUMMARY AND INDEX

The following summaries and indices may prove helpful to those interested in tab-
ulations and to those who may wish to examine theses in the same or related fields.

Index to Masters' theses by departments. The departments are arranged alphabe-
tically. Under each department are listed alphabetically the names of the authors.

Masters' theses accepted July 1, 1952 - June 30, 1953 = 194.

Agricultural Engineering - Total 6.
  Jacob, Mamisao, Pederson, Sandahl,
  Snell, Walpole.
Agronomy - Total 17.
  Bouldin, Brigham, Brown, C.N., David-
  son, Fiuzat, Gray, Green, Jarvis, Kuksis,
  Maasland, Mack, Newlin, Schonhorst,
  Stritzel, Thomas, White, Yermanos.
Animal Husbandry - Total 8.
  Alston, Cobb, Fincham, Francis, Heg-
  land, Lane, Nelson, Young.
Applied Arts - Total 2.
  Held, Navin.
Architectural Engineering - Total 2.
  McKeown, Slater.
Bacteriology - Total 1.
  Schwartz.
Botany and Plant Pathology - Total 4.
  Brown, C.N., Delouche, Monson,
  Wintersteen.
Chemical Engineering - Total 7.
  Anderson, Cohen, Crowley, Edwards,
  Goldstein, Pflasterer, P'Pool.
Chemistry - Total 22.
  Bauriedel, Bowers, Byrd, Cessna,
  Champaigne, DeFontaine, Drechsler,
  Ellingboe, Ellinger, Freelander, Hanna,
  Janssen, Lohman, Lunt, Mosser,
  Priesthoff, Smith, A.G., Smith, Q.T.,
  Suhadolnik, Tabeling, Tracy, Weiner.
Civil Engineering - Total 4.
  Ally, Chin, Larson, Nichols.
Economics and Sociology - Total 14.
  Allen, Basmann, Bivens, Bodensteiner,
  Carothers, Clupper, Harper, Kolmer,
  Manderscheid, Nichols, Olson, Ralph,
  Seagraves, Stoneberg.
Electrical Engineering - Total 2.
  Nilsson, Walter.
Engineering - Total 3.
  Henson, Macauley, Truax.
Foods and Nutrition - Total 5.
  Edgar, Porter, Schubert, Smith, Stan-
  derfer.
Forestry - Total 1.
  Eschner.

Genetics - Total 2.
  Cale, Rothenbuhler.
Geology - Total 2.
  Wilcox, Williams.
Home Management - Total 2.
  Holaday, McKeegan.
Household Equipment - Total 3.
  Banister, Beale, Smith.
Institution Management - Total 4.
  Burford, Emmons, Galster, Rogers.
Mathematics - Total 2.
  Johnson, R.E., Karwhath.
Mechanical Engineering - Total 1.
  Blakemore.
Physics - Total 4.
  Barker, Mueller, Pearson, Pohm.
Poultry Husbandry - Total 1.
  Farnsworth.
Psychology - Total 9.
  Boldt, Clark, Facto, Fox, McNelly,
  Schmitz, Schumacher, Stone, Vavra.
Statistics - Total 10.
  Gaylor, Hameed, Henry, Ives, Lomeli,
  Magistad, Radwan, Ross, Wilk, Zoellner.
Technical Journalism - Total 2.
  Brown, M.E., Gittinger.
Textiles and Clothing - Total 1.
  Patson.
Theoretical and Applied Mechanics -
  Total 2. Arbtin, Young.
Vocational Education - Total 37.
  Baker, Bell, Brown, V.O., Burnham,
  Cleveland, Coleman, Crane, Dawson,
  Doty, Freeman, Fribourgh, Gaines,
  Gienapp, Gordon, Grainge, Harger,
  Johnson, L., Johnson, W., Jones, Kjer-
  land, Lewis, Mahaney, Mahon, Moor-
  head, Parks, Ruby, Rust, Rutz, Shel-
  don, Suhr, Suzui, Viilo, Weber, Weller,
  Willard, Williams, Woolverton.
Zoology and Entomology - Total 16.
  Boles, Cabalka, Cox, Douglas, Fair-
  child, Forney, Gooden, Hansen, Kline,
  Koning, Pearcy, Rothenbuhler, Swift,
  Thompson, Thornburg, Vil.

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* A list of Masters' theses accepted July 1, 1951 — June 30, 1952 is included in No. 2,
Vol. 27 of the Iowa State College Journal of Science.

# AUTHORS AND TITLES

## MASTERS' THESES

The titles of theses are arranged in alphabetical order by names of authors. Each listing includes the name of the author, the title of the thesis, and the department.

(428)

Champaigne, John Fred Jr. N-substituted phenothiazine derivatives. Chemistry.

Chin, Timothy Kwet-Fah. Properties for numerical analysis of frames with curved girders. Civil Engineering.

Clark, John Garold. A validation study of the Worthington Personal History blank. Psychology.

Cleveland, Iola Zoe. Certain factors related to the use of time by home economics students in one high school. Vocational Education.

Clupper, Darwin Diehl. Personal and social factors related to community activities of 90 selected Iowa ministers. Economics and Sociology.

Cobb, Estel Herman. Lean cuts and fatness as related to rate and economy of gain in swine. Animal Husbandry.

Cohen, Robert Mortimer. Performance of a pulse extraction column. Chemical Engineering.

Coleman, Ruby Watts. Some factors affecting the satisfaction of Negro home-making teachers in Mississippi. Vocational Education.

Cox, H.C. Chemical control of the corn rootworm, Diabrotica longicornis (Say), in Iowa. Zoology and Entomology.

Crane, Henry Lu dlow. Forecasting at the ninth grade level future formal education and type of vocation. Vocational Education.

Crowley, Paul Rodney. Continuous preparation of a fine oxide suspension. Chemical Engineering.

Davidson, Steve Edwin. Time, rate and method of application of phosphate fertilizer. Agronomy.

Dawson, Mattie Sue. Re lative importance of certain problems for a college home furnishings course. Vocational Education.

DeFontaine, Dorothy Elizabeth. Quantitative chemical distribution of amino nitrogen from leaves of two strains of corn. Chemistry.

Delouche, James Curtis. Influence of moisture and temperature levels on the germination of corn, soybeans and watermelons. Botany and Plant Pathology.

Doty, Vernon Elsten. Occupational distribution of the 1948 and 1949 graduates, Abraham Lincoln High School, Council Bluffs, Iowa. Vocational Education.

Douglas, Earle Milton. Effect of certain fumigants on the survival rate of Sitophilus oryza. Zoology and Entomology.

Drechsler, Edward Robert. Utilization of certain benzoylamino acids by several species of bacteria. Chemistry.

Edgar, Margaret Ann. Palatability of turkey cooked with and without wrapping in aluminum foil at two oven temperatures. Foods and Nutrition.

Edwards, Robert Boyd. Activation of silica gel in a roto-louvre dryer. Chemical Engineering.

Ellingboe, John LaVerne. Acid amide groups of vitamin $B_{12}$. Chemistry.

Ellinger, Rudolph Henry. Separation of the component peptides of bacitracin. Chemistry.

Emmons, Esther Hermione. Lunch programs in Iowa schools with grades one through twelve. II. Cost and participation. Institution Management.

Eschner, Arthur Richard. Growth and composition of oak stands on the Brayton Forest in relation to soil and topography. Forestry.

Facto, Joseph John. Differential academic prediction from a paragraph comprehension test. Psychology.

Fairchild, Mahlon Lowell. Influence of nozzle arrangements and spray volumes on second brood European corn borer control. Zoology and Entomology.

Farnsworth. George Morris, Jr. Genetic differences in factors of egg quality. Poultry Husbandry.

Fincham, Robert Charles. Response of dairy heifers to aureomycin feeding. Animal Husbandry.

Fiuzat, Yahya. Genetic and environmental variability in segregating barley populations. Agronomy.

Forney, John Latimer. Life history of the black bullhead (Ameiurus melus) of Clear Lake, Iowa. Zoology and Entomology.

Fox, Marilyn Louise. Employee attitudes in a midwestern insurance company. Psychology.

Francis, Eugene Nelson. Use of stilbestrol in fattening rations. Animal Husbandry.

Freeland, Max Quentin. The Komarowski reaction with benzaldehyde and tertiary alcohols. Chemistry.

Freeman, James Woodrow. Certain psycho-sociological factors of accident-free and accident-liable automobile drivers of Cedar Rapids, Iowa. Vocational Education.

Fribourgh, Gunder Frederick. Predicting achievement in machine shop, printing, auto-diesel and aviation engine courses at Des Moines Technical High School. Vocational Education.

Gaines, Mary Pumphrey. Experiences récommended for the home economics program by girls in grades seven through nine of Dunbar High School, Little Rock, Arkansas. Vocational Education.

Galster, Marion Dorothy. Criteria for certain aspects of institution management curricula. Institution Management.

Gaylor, David William. A statistical eval-
uation of techniques and choice of esti-
mators in grazing experiments with
feeder cattle in Iowa. Statistics.

Gienapp, William H. Services offered in
small communities in Eastern Iowa
whose high schools were closed between
1939 and 1949. Vocational Education.

Gittinger, James Price II. Journalistic
aspects of a joint farmer cooperative
education program for an Iowa commu-
nity. Technical Journalism.

Goldstein, David. Determination of the
thermal conductivity of molten lithium.
Chemical Engineering.

Gooden, Samuel Knapp. Winter behavior
of the eastern bob-white, Colinus vir-
ginianus virginianus L. on the Decatur
County Research Area, 1951-1952.
Zoology and Entomology.

Gordon, Evelyn Sandra. Relation of selec-
ted factors to four types of reasons
checked by Iowa women for attending
adult homemaking classes. Vocational
Education.

Grainge, Floyd Marvin. Survey of methods
used in supervision of student teaching.
Vocational Education.

Gray, Robert Copping. Evaluating the
phosphorus and potassium status of
some Southeastern Iowa soils.
Agronomy.

Green, Alexander James. Properties of
some profiles of the Hayden series.
Agronomy.

Hameed, Abdul. Choice of plot size for the
objective estimation of corn yield.
Statistics.

Hanna, George Frederick. Light scatter-
ing and flow birefringence studies of
ovalbumin denatured by surface active
ions. Chemistry.

Hansen, Donald Waldemar. Life history
studies of the trout of Pathfinder Res-
ervoir, Wyoming. Zoology and Ento-
mology.

Harger, Robert Dean. Prediction of the
tendency of Fort Dodge junior high
school students to matriculate in college.
Vocational Education.

Harper, Dean Harrison. Some scaling
techniques applied to the study of aware-
ness of selected social problems.
Economics and Sociology.

Hegland, Robert Basil. Factors affecting
reflex closure of the esophageal groove
in the calf. Animal Husbandry.

Held, Shirley Elaine. Original fabric and
accessory design for women's clothes.
Applied Art.

Henry, Kenneth Alvin. Statistical analysis
of the chum salmon (Oncorhynchus keta)
data for Tillamook Bay. Statistics.

Henson, Alton Ray. Effects of the degree

of lamination on the efficiency of radia-
tion shielding. General Engineering.

Holaday, Helen Lucile. Expenditure pat-
terns of selected Iowa farm families
keeping home accounts, 1940-1949.
Home Management.

Ives, William George Herbert. Estimation
of potential populations of the European
larch sawfly, Pristiphora erichsonii
(Hartig). Statistics.

Jacob, Connayil Mani. Effect of certain
nail characteristics upon rupture resis-
tance of sheet aluminum. Agricultural
Engineering.

Janssen, Frank Walter. Enzymic specifi-
city in peptide bond synthesis. Chemistr

Jarvis, Genole Jennings. Differential res-
ponse of oat varieties to nitrogen ferti-
lization and drill-row spacings.
Agronomy.

Johnson, Louise. Problems related to
child development recognized by high
school girls in North Dakota. Vocationa
Education.

Johnson, Richard Earl. Loxodromic trans-
formations of the complex plane.
Mathematics.

Johnson, Wilbur. Instruction in Agricul-
tural cooperation by Negro teachers of
vocational agriculture and of farm vet-
erans in Georgia. Vocational Education.

Jones, George McIntyre. Establishment in
farming of present and former Negro
pupils of vocational agriculture in Leake
County, Mississippi. Vocational Educa-
tion.

Karwhath, Arthur Alonzo. Schwarz-Chris-
toffel transformation. Mathematics.

Kjerland, Reginald Norman. Finger, leg,
lip and voice reaction time under two
experimental conditions. Vocational
Education.

Kline, Paul D. Autumnal decimations of
Mearns cottontail in Decatur County,
Iowa, 1952. Zoology and Entomology.

Kolmer, Lee Roy. Costs of drying butter-
milk in Iowa creameries. Economics
and Sociology.

Koning, Alice Louise. Localization of en-
zyme systems and nucleic acids in the
developing down feather of the chick.
Zoology and Entomology.

Kuksis, Arnis. Comparative studies of
root tissues, juices and bacterial com-
patability of two sister strains of the
soybean, Glycine max (L) Merrill.
Agronomy.

Lane, Malcolm Daniel. Effect of feeding
antibiotics on the absorption of certain
nutrients in swine. Animal Husbandry.

Larson, Vincent E. Effect of recirculat-
ing sewage through a trickling filter.
Civil Engineering.

Lewis, Mary Inez. Evaluation of chapter

activities of "New Homemakers of America" in five states. Vocational Education.

ohman, Fred Herman. Properties and salts of 5, 8-dihydroxyquinoline. Chemistry.

omeli, Maria Guadalupe. Approximate methods in the classification of populations. Statistics.

unt, Harry Edward. Thorium-titanium alloy system. Chemistry.

McKeegan, Margaret L. Techniques and problems of presenting homemaking television programs. Home Management.

McKeown, Donald Irvin. An evaluation of the architectural design philosophy of Louis H. Sullivan as reflected in his work in the midwest. Agricultural Engineering.

McNally, George Winfield. Reminiscence as a function of block weight and length of interpolated rest in a manipulative task. Psychology.

Maasland, Marinus. Tile drainage in anisotropic soils. Agronomy.

Macauley, Bill Thomas. Simplification of multigroup reactor theory. General Engineering.

Mack, Alexander, Fertilization of spring grain to overcome the influence of immobilization of nitrogen and phosphorus by decomposing straw residues. Agronomy.

Magistead, John Gilbert. Statistical indices of soil aggregation. Statistics.

Mahaney, Robert Eugene. Technique of selecting pupils for high school woodworking. Vocational Education.

Mahon, Robert Dines. Prediction of achievement in a radio course at the American Technical School. Vocational Education.

Mamisao, Jesus P. Development of an agricultural watershed by similitude. Agricultural Engineering.

Manderscheid, Lester Vincent. Consumer expenditures as a measure of demand for food. Economics and Sociology.

Monson, Paul Herman. Marsh and aquatic dicotyledonous flora of Iowa. Botany and Plant Pathology.

Moorhead, David Lincoln. A proposed community school district for Boone, Iowa. Vocational Education.

Mosser, John D. Resolution of DL-phenylalanine by the quaternary base of methyl cinchonine. Chemistry.

Mueller, William John. Scintillation crystal pulses from heavy particles. Physics.

Navin, Janet Louise. Original designs for contemporary interiors, fabrics and dual- and triple-purpose furniture. Applied Art.

Nelson, LeRoy Frederick. Development of practical synthetic milk formulas for baby pigs. Animal Husbandry.

Newlin, Owen Jay. Water loss from grain and associated plant parts of corn after physiologic maturity. Agronomy.

Nichols, Frank Arthur. Effects of recommended land use upon land productivity and crop production. Economics and Sociology.

Nicholls, Robert Lee. Preliminary investigations for the chemical stabilization of loess of Southwestern Iowa. Civil Engineering.

Nilsson, James William. A low-mounted fluorescent luminaire for highway lighting. Electrical Engineering.

Olson, Francis John Robert. Economics of the soybean enterprise. Economics and Sociology.

Parks, Orrin Ralph. Probability of industrial education graduates entering teaching or non-teaching vocations. Vocational Education.

Patson, Nellie Katherine. Prediction of construction achievement using Saddler clothing test, dexterity questionnaire and four spatial relations tests. Textiles and Clothing.

Pearcy, William Gordon. Some limnological features of Clear Lake, Iowa. Zoology and Entomology.

Pearson, George John. Method for determination of deuterium photo-disintegration cross sections for 20-70 mev X-rays. Physics.

Pederson, John Hallett. Elastic properties of bent and sawed curved rafters. Agricultural Engineering.

Pflasterer, James Lee. Reaction of the sodium salt of some 2-hydroxyminocycloalkanones with hydroxylammonium chloride. Chemistry.

Pohm, Arthur Vincent. Decay schemes of some rare earth isotopes by beta-ray spectroscopy. Physics.

Porter, Barbara Anne. Factors affecting nitrogen balance of protein-depleted rats receiving restricted calories. Foods and Nutrition.

P'Pool, Robert Sterling. Effects of operating variables on the continuous solvent extraction of vegetable oils. Chemical Engineering.

Priesthoff, John Howard. The preparation, purification and some analytical applications of alpha, beta, gamma, delta-tetraphenylporphine. Chemistry.

Radwan, Mohamed Hassan Saleh. Serial correlation. Statistics.

Ralph, James Tyree. Economic analysis of the commercial mixed feeds industry with special reference to Iowa. Economics and Sociology.

Rogers, Cora Belle. Lunch programs in
Iowa schools with grades one through
twelve. I. Contributions of USDA donat-
ed commodities. Institution Manage-
ment.

Ross, Allan. A modification of the Hartley-
Politz scheme for dealing with "not-at-
home" persons. Statistics.

Rothenbuhler, Walter Christopher. Origin
of gynandromorphic honey bees. Gene-
tics; and Zoology and Entomology.

Ruby, Donald Warren. Effectiveness of a
motion picture and a demonstration in
teaching a unit on fuses in basic electri-
city. Vocational Education.

Rust, Bethel Eleanor. Characteristics of
Iowa women related to certain reasons
for attending adult homemaking classes.
Vocational Education.

Rutz, Harold Friedrich. Strength of sev-
eral types of glue as applied to various
species of wood used in industrial arts
shops. Vocational Education.

Sandahl, Everett Martin. Tests of the ef-
fect of rotor size and reversible feature
on the performance of a whirlwind type
terracer. Agricultural Engineering.

Schmitz, Roy Melvin. Relationship of cer-
tain measured abilities to freshman
engineering achievement. Psychology.

Schonhorst, Melvin Herman. Genetic and
environmental relationships of oil con-
tent and agronomic characters in ad-
vanced generations of a soybean cross.
Agronomy.

Schubert, Genevieve Weber. Effect of low
vitamin $B_{12}$ intake on reproduction in
rats. Foods and Nutrition.

Schumacher, Charles Fredrick. An exper-
imental study of the validity of a paper
and pencil test of visual acuity.
Psychology.

Schwartz, Miriam. Methionine synthesis
by mutants of Aerobacter aerogenes.
Bacteriology.

Seagraves, James Arthur. Productivity of
agricultural resources in Iowa from
1950 census data. Economics and
Sociology.

Sheldon, John Mitchell. Relationship of
temperament traits of teachers to level
of teaching. Vocational Education.

Slater, Bernard James. Problems, poli-
cies and designs of multiple housing
units in Sweden and United States, 1932-
1952. Architectural Engineering.

Smith, Arthur Gerald. Some cleavage re-
actions of alkyl and aryl silanes.
Chemistry.

Smith, Leslie D. Walters. Physical de-
velopment in relation to food habits of
100 Iowa children over a three-year
period. Foods and Nutrition.

Smith, Quenton Terrill. Levels of certain

B vitamins in calf blood as affected by
feeding aureomycin. Chemistry.

Smith, Reba Annette. Factors affecting
time required for freezing in four home
freezers. Household Equipment.

Snell, Absolom West. Settlement of ter-
races constructed on two Iowa soils.
Agricultural Engineering.

Standerfer, Susan Bow. Reproduction and
lactation of rats fed eight experimental
rations. Foods and Nutrition.

Stone, James Albert. Effect of wavelength
contrast on discrimination thresholds
under mesopic vision. Psychology.

Stoneberg, Everett George. Income com-
parison of land use programs in Western
Iowa. Economics and Sociology.

Stritzel, Joseph A. Effect of phosphate
placement on early growth of corn.
Agronomy.

Suhadolnik, Robert Joseph. Oxidation of
disaccharide alcohols by Acetobacter
suboxydans. Chemistry.

Suhr, Virtus William. Relationship of per-
sonality traits and certain psycho-socio-
logical factors to driving performance of
commercial drivers. Vocational Educa-
tion.

Suzui, Richard Shigeru. Needs for instruc-
tion in farm mechanics in Hawaii. Voca-
tional Education.

Swift, Fred Calvin. Effects of lindane seed
treatments on germination and early
growth of field corn. Zoology and Ento-
mology.

Tabeling, Raymond William. Spectrogra-
phic determination of scandium, thulium,
ytterbium and yttrium in purified lutet-
ium. Chemistry.

Thomas, Walter Ivan. Heritability and in-
terrelation of popping volume and some
agronomic characteristics in popcorn.
Agronomy.

Thompson, William Walter. Localized ap-
plications of DDT to the corn plant and
their effects on corn borer mortality
(Pyrausta nubilalis Hubner).
Zoology and Entomology.

Thornburg, Margaret Ann Cochran. Effect
of insecticides on the rate of pulsatile
organs in the legs of Myzus persicae
Sulzer. Zoology and Entomology.

Tracy, George Abner. Magnesium-uran-
ium alloy system. Chemistry.

Truax, Robert Collins. Charging systems
for electrostatic generators. Engineer-
ing.

Vavra, Lewis Robert. Sex differences in
certain factors of space judgment under
conditions of mesopic vision. Psychology

Viilo, Wesley Michael. Industrial arts
general metalwork for secondary school
Vocational Education.

Vil, Edner. Influence of dietary fat on

susceptibility of <u>Dermestes</u> <u>maculatus</u>
De Geer to selected insecticides.
Zoology and Entomology.

Walpole, Ernest Wilfred. Flexural prop-
erties of corrugated aluminum roofing.
Agricultural Engineering.

Walter, Richard Kurt. Remote control de-
vices for the network analyzer. Elec-
trical Engineering.

Weber, Robert Gene. Practices related
to guidance information in the Iowa pub-
lic high schools. Vocational Education.

Weiner, Lazarus Carl. Temperature de-
pendence of electrical resistivity of
metals. Chemistry.

Weller, Egbert Douglas-Haig. Education-
al measures for agrarian reform in
Jamaica. Vocational Education.

White, William Calvin. Experimental
tests of the inverse yield-nitrogen law.
Agronomy.

Wilcox, Ronald Erwin. Structural Geology
of the Garden of the Gods, Colorado.
Geology.

Wilk. Martin Bradbury. The randomiza-
tion analysis of a generalized random-
ized block design. Statistics.

Willard, Charles Osborn. Prior achieve-
ment, aptitudes and interests associat-
ed with the election of senoir high
school sciences. Vocational Education.

Williams, Elsie Kimbrell. Effectiveness
of television as a teaching medium for
clothing construction. Vocational
Education.

Williams, Wayne Watson. Fundamental
properties of five Iowa sands. Geology.

Wintersteen, Hugh George. Response of
clonal lines of <u>Bromus</u> <u>inermis</u> to infec-
tion by <u>Selenophoma</u> <u>bromigena</u>.
Botany and Plant Pathology.

Woolverton, Charlene Lee. Differences in
opinions of mothers and daughters about
suitable content for eighth grade home
economics courses. Vocational Educa-
tion.

Yermanos, Demetrios Mathew. Compara-
tive efficiency of three methods of iso-
lating inbred lines of corn. Agronomy.

Young, Donald Fredrick. Flow of aqueous
suspensions of rounded glass particles.
Theoretical and Applied Mechanics.

Young, Frank Benjamin. Hydrogenated
soybean oil and dried whey product in
whole milk replacements for dairy
calves. Animal Husbandry.

Zoellner, John Arthur. Experimental de-
signs with blocks of two plots. Statistics.

# PUBLICATIONS OF MEMBERS OF THE STAFF
## OF THE IOWA STATE COLLEGE FOR
### THE ACADEMIC YEAR 1952-53

Certain summaries and indices are of interest in a survey of the publications of members of the staff of an educational and research institution such as the Iowa State College. The publications are listed in alphabetic order under the names of the senior authors. Junior authors are also listed alphabetically with cross reference to senior author.

## SUMMARY

The individuals thus serving are: Bartley, Benbrook, Brosier, Burroughs, Carlander, Douglas, Gaskill, Gilman, Gowen, Heady, Heath, Heer, Hooker, Johnson, Kirkham, Loomis, Murphy, Nelson, Parks, Pierre, Tintner, Underkofler, Weber.

## INDEX TO PUBLICATIONS BY DEPARTMENTS OR FIELDS

The numbers which follow the names of the departments refer to the index number of the alphabetic list by authors.

## AUTHORS AND PUBLICATIONS

1. Aboul-Ela, M.M. Physiological changes and freezing injury in maturing maize. Plant Physiol. 27:778-786. 1952.
2. Adams, A.T., J.C. Ayres, R.G. Tischer, and B. Ostle. Effect of subtilin on spoilage of thermal processed beef. Food Tech. 6:421-424. 1952.
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_____, joint author. See under Gross, Thompson.
4. Albers, H.H. Frederick W. Taylor: An evaluation. Current Econ. Comment. 15 (No. 2):45-50. 1953.
5. _____. Scientific job seeking; how to get the job you want. Littlefield, Adams and Co., Paterson, N.J. 1st ed. 69 pp.
6. _____. Union jurisdiction. Labor Law Jour. (Commerce Clearing House, Chicago). 4:183-195. 1953.
Allen, R.S., joint author. See under Murley, Zaletel.
Alsmeyer, W.C., joint author. See under Kerekes.
7. Altman, L.B., G.C. Ashton, and D. Catron. Your pigs may need more water. Iowa Farm Sci. 7:41-42. 1952.
8. Altshuler, S. Applications of variational principle to scattering problems. Phys. Rev. 89:1278-1283. 1953.
9. _____. Excitation cross section for helium atoms I. Phys. Rev. 89:1093-95.1953.
Anderson, D., joint author, See under Fassel.
Anderson, E.E. Jr., joint author. See under Smith.
0. Anderson, R.L., and T.A. Bancroft. Statistical theory in research. McGraw-Hill Book Co., N. Y. 1st ed. 399 pp. 1952.
1. Arbtin, E. Jr., and G. Murphy. Correlation of Vickers hardness number, modulus of elasticity and the yield strength of ductile metals. U.S. Atom. Energy Comm., Ames Lab. Rept. I.S.C. 356:1-28. 1953.
_____, joint author. See under Murphy.
Arbuthnot, K.D., joint author. See under Blickenstaff.
2. Arnold, L.K., and D.J. Patel. Effect of moisture on the rate of solvent extraction of soybeans and cottonseed meals. Jour. Amer. Oil Chem. Soc. 30:216-218. 1953.
3. _____, and R.M. Carvey. Preliminary studies on the application of certain chlorinated solvents to soybean oil extraction. Jour. Amer. Oil Chem. Soc. 30:81-83. 1953.
_____, joint author. See under Balloun, Burnet, Sweeney.
4. Aronoff, S. The chemistry of chlorophyll (with special reference to food). Academic Press, N. Y. Advances in Food Research, Vol. 4:133-184. 1953.
5. _____. Chlorophyll, III. Analytical, chemical and technological aspects. Academic Press, Inc., N.Y. Chapter in Advances in Food Research. IV:133-184. 1953.
6. _____. Use of $C^{14}$ in carbohydrate metabolism studies, in "Use of Isotopes in Plant and Animal Research". U.S. Atom. Energy Comm., Wash., D.C. TID 5098:227-241. 1953.
7. _____. The action of invertase preparations. II. Arch. Biochem. and Biophys. 41:476-478. 1952.
_____, joint author. See under Racusen.
Ashton, G.C., joint author. See under Altman, Catron, Nelson, Quinn.
8. Atkins, R.E., and C.S. Reddy. Response of flax varieties to seed treatment. Plant Dis. Reporter. 37:230-231. 1953.
9. _____, C.S. Reddy, and D.W. Staniforth. What's new in flax farming. Iowa Farm Sci. 7:185-186. 1953.
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